Product Data

Real-time Frequency Analyzer — Type 2143
Dual Channel Real-time Frequency Analyzers — Types 2144, 2148/7667

USES:

- ❍ Sound intensity measurements to IEC 1043
- ❍ Constant-percentage bandwidth frequency analysis of sound and vibration signals in real-time
- ❍ Noise source location and source ranking of complicated structures (2144, 2148/7667)
- ❍ Environmental noise measurements. Includes Taktmaximal
- ❍ Building acoustics testing: sound transmission, absorption, reverberation time
- ❍ Automotive acoustic and vibration testing
- ❍ In situ sound power measurements (2144, 2148/7667)

FEATURES:

- ❍ IEC 651/804 Type 1 accuracy (with suitable microphone)
- ❍ Weight with batteries <10 kg (< 22 lbs)
- ❍ Battery life-time > 4 hrs continuous use
- ❍ Inputs: microphone (preamplifier), sound intensity probe (2144, 2148/7667), accelerometer (charge) and direct
- ❍ Real-time frequency analysis up to 22.4 kHz (single channel), 11.2 kHz (dual channel)
- ❍ 80 dB dynamic range, autocalibration
- ❍ Fractional-octave digital filters
- ❍ Storage rate: 1000 spectra/second (single channel), 500 spectra/second (dual channel)
- ❍ Large internal non-volatile memory
- ❍ PC/MS–DOS compatible $3^1/_2$″ disk-drive for back-up storage of spectra and set-ups
- ❍ IEEE–488 and RS–232 interfaces
- ❍ Zwicker Loudness and FFT application programs available

Real-time Frequency Analyzers Types 2143 and 2144, 2148/7667 are portable analyzers for acoustics, electroacoustics and vibration measurements in the field and in the laboratory. Type 2143 offers dual-channel autospectra while Types 2144 and 2148/7667 also offer sound intensity and cross spectrum analysis. The analyzers feature real-time digital filtering across a wide frequency range. Real-time operation is important for the analysis of non-stationary signals such as decays and impulsive events.

The analyzers are operated by means of menus, and a system of on-screen help pages enables the full potential of the analyzers to be used in the field.

The large internal non-volatile memory and back-up disk storage facilities make the analyzers useful data-gathering devices with further control and data-processing possibilities via their IEEE–488 and RS–232 interfaces.

Introduction

Real-time Frequency Analyzers Types 2143 and 2144 are robust analyzers, 18 × 36 × 29 cm in size and weighing less than 10 kg including batteries. The power supply provided is used for powering the analyzer in the laboratory or for recharging the batteries. Fully charged batteries give more than 4 hrs of continuous operation in the field.

Type 7667 is a dual-channel software options for Dual Channel Portable Signal Analyzer Type 2148 (see separate Product Data – BP 1285), which converts its operation to be identical to that of 2144.

With the exception of the analogue input modules (input amplifiers, filters, attenuators and antialiasing filters), the analyzers are digital instruments. This means that their calibration is extremely stable, exhibiting no drifting effects.

The internal spectrum memory can hold several hundred spectra. This memory is non-volatile so that saved data is protected against power failures. Back-up memory storage is provided by a built-in PC/MS-DOS compatible disk-drive. Disks are transferable to laboratory analyzers such as Brüel & Kjær Real-time Frequency Analyzers Types 2123 and 2133 (BZ 5027 software required) or to a computer for further processing of spectra. Remote-control commands and measurement data can be sent directly over the IEEE–488 parallel interface or the RS–232 serial interface.

The analyzers operate in real-time when measuring in $^1/_1$- or $^1/_3$-octaves. For $^1/_{12}$- and $^1/_{24}$-octave analysis there is a choice of real-time analysis over a limited frequency range or multi-pass analysis over the full frequency range. Multi-pass analysis involves processing signals from batches of filters in sequence, rather than from all filters simultaneously. This approach to analysis is valid for stationary or repeatable signals. Fig. 1 shows the frequency ranges for real-time and multi-pass analysis in single channel operation.

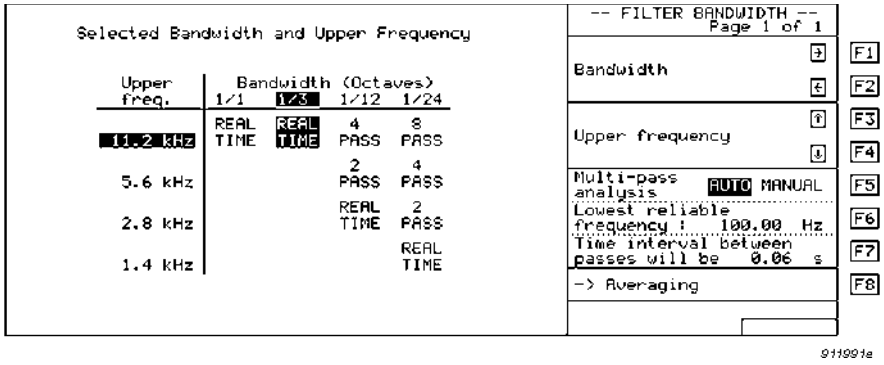

Fig. 1 Frequency ranges for real-time and multi-pass analysis (dual channel)

Input/Output

Real-time Frequency Analyzers Types 2143, 2144 and 2148/7667 have inputs on the back panel (see Fig. 2) for connecting accelerometers, microphone preamplifiers, a sound intensity probe and direct electrical signals, and also have RS–232 and IEEE–488 input/output interfaces.

Each of the signal inputs has a dynamic range of more than 80 dB. Instantaneous overloads are indicated by an LED on the front panel. Cumulative overload indications are given on the screen as the percentage of the elapsed averaging time for which overload has occurred. Three different high-pass filters with –0.1 dB cut-off frequencies of 0.7 Hz (0.3 Hz for charge input), 20 Hz or 100 Hz can be selected for all inputs. In addition, an analogue A-weighting filter can be selected for the microphone preamplifier input and the direct input. Pre-A-weighting allows SLM-type measurements to be made, fulfilling IEC 651 type 1.

Microphone Preamplifier Input

The 7-pin Preamplifier Input socket supplies power for the microphone preamplifier, and a selectable polarization voltage of 0 V, 28 V or 200 V, enabling connection of most types of Brüel & Kjær measurement microphones.

Probe/Remote Control Handle Input (2144, 2148/7667)

An 18-pin socket provides a convenient single-cable connection for Sound Intensity Probe Type 3548, and includes microphone polarization voltage and power supply for the preamplifiers.

Accelerometer Input

The analyzers have built-in charge sensitive preamplifiers with two micro connectors. The input signal measuring range is adapted to the wide range of Brüel & Kjær accelerometers.

Direct Input

Voltage signals are connected to the preamplifier input via Lemo-to-BNC adaptors (included as accessories). Input coupling is AC.

Analogue to Digital Conversion

The analyzer has a 16- bit delta-sigma A/D-converter and a third order analogue anti-aliasing filter giving at least 80 dB attenuation of aliasing frequencies.

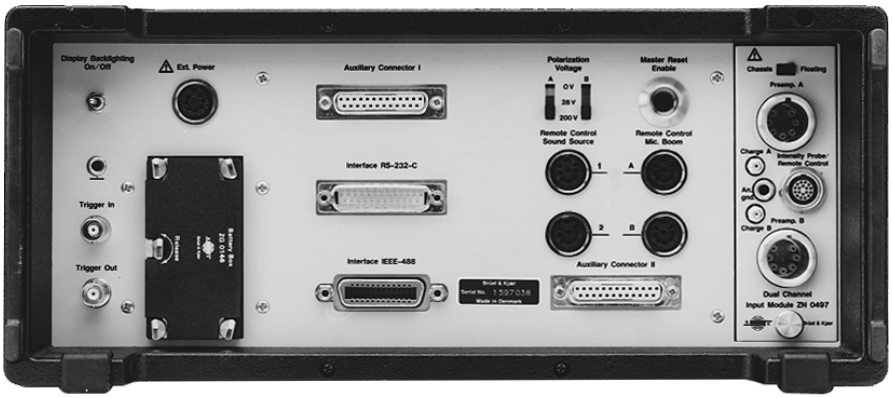

Fig. 2 Back panel of Type 2144

Interface

For integration of the analyzer into a larger measurement system under computer control, the IEEE–488 parallel interface provides convenient access to all raw and processed data in the analyzer. It also provides complete control of all the front panel and "soft" functions. The default state of the parallel interface is "on" when the analyzer is first powered up.

The RS–232 serial interface provides similar remote control possibilities and is particularly suited for field data processing applications in conjunction with a battery-operated lap-top computer.

Hard Copy

A selection of print formats are included in the analyzers for direct printing of screen pictures on IBM, Hewlett Packard or Epson printers. Such a print-out can be obtained simply by pressing ⟨**Hard Copy**⟩ on the front panel (Fig. 3).

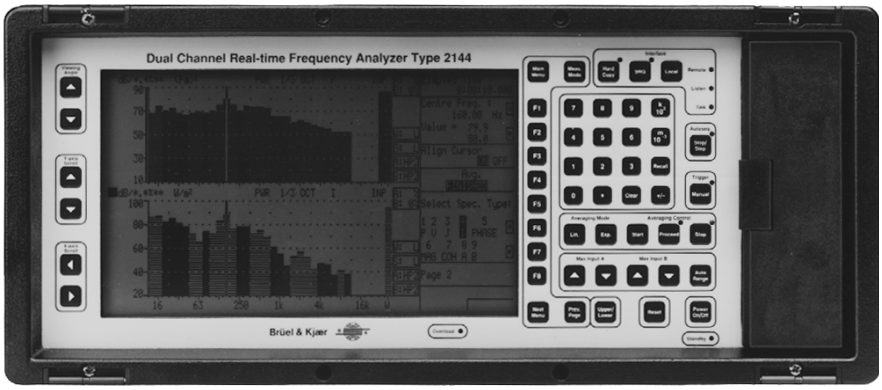

Fig.3 Front panel of Type 2144

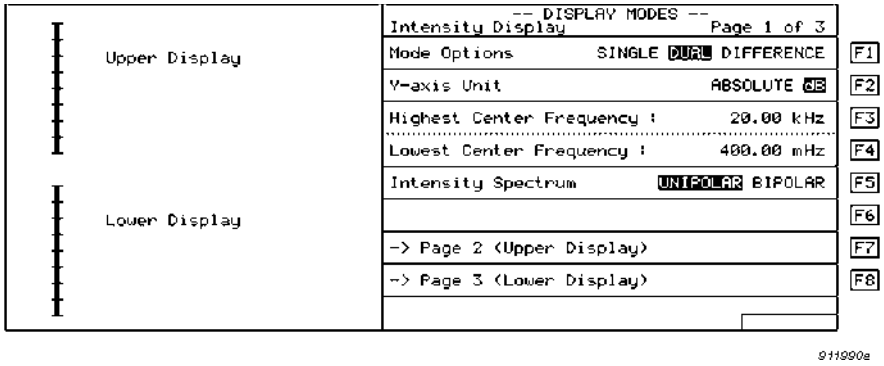

Fig.4 Display modes available: single, dual, and difference

Display

The LCD can display all or any part of the 80 dB dynamic range of a spectrum. Fig. 4 shows the display formats available. "Single" displays the input spectrum at maximum resolution. "Dual" simultaneously displays two input or recalled spectra or an input spectrum and a recalled spectrum. "Difference" displays (in the upper display) the dB difference between an input spectrum and the spectrum in the lower display. A fourth option, the "slice" display, is available for viewing multispectra after the completion of a measurement. Multispectra are discussed later.

Back Lighting

Display back lighting can be switched on or off as required. As a power-saving feature, the back lighting can be set to switch off automatically when the analyzer's pushkeys have not been used for a user-specified period of time.

A/L-, I- and W-channels

The A/L-, I- and W-channels are shown in the display immediately to the right of the frequency spectrum (see for example Fig. 3). The A/L-channel shows the overall level of the spectrum measured with a broadband linear ("L") or A-weighting ("A") filter.

The broadband level of a weighted spectrum is shown in the W-channel. The level is calculated on the basis of the band-pass filter outputs. A weighting function (which may be linear) can be applied independently to the whole spectrum, the W-channel, or both. Impulse averaging can be applied to broadband measurements and uses fixed time constants of 35 ms while the signal is rising and of 1.5 s when it is falling. When switched on, the I-channel replaces W-channel measurements.

Operation

Set-up Mode/Measurement Mode

Operation is divided into two modes: Set-up Mode and Measurement Mode.

Set-up Mode is used for configuring the analyzer and can be stepped through systematically until the analyzer is fully configured with, for example, the Measurement Type, the required frequency range, the axes of the display, filter bandwidth, and averaging mode. Fig. 5 shows the first page of the menus accessible using the "soft keys" ⟨**F1**⟩ to ⟨**F8**⟩ on the analyzer's front panel.

In order to make measurements, the analyzer must be put in Measurement Mode (hard key on front panel). In this mode, there is still access to some of the most important set-up parameters, such as averaging and display range. Fig. 6 shows a typical display in Measurement Mode (Types 2144 and 2148/7667).

Help Pages

Once a menu has been called to the screen, it can be alternated with an associated help page. The help pages, one for each menu page, provides sufficient information for field operation of the analyzer without reference to an instruction manual.

Overview of Settings

All menu settings relevant for the selected Measurement Type (see below) are displayed in summarized form in the Current Set-up menu (Fig. 7). The analyzer set-up consists of three parts: Measurement Set-up, Display Set-up and Calibration Set-up. A copy of the Current Set-up is saved along with all measurement results so that results are fully documented. When the analyzer is switched off, the Current Set-up is preserved in the non-volatile memory so that when the analyzer is next switched

on, the settings are exactly as they were previously.

Pre-configured Set-ups

Factory-programmed default settings for acoustics and vibration measurements are permanently available to enable quick measurements. Up to four complete user-defined set-ups can be saved in the non-volatile memory to enable rapid reconfiguration of the analyzer during field measurements. The user-defined set-up or any part of it (Measurement, Display or Calibration Set-up) can be activated. The activated parts of the set-up overwrite the Current Set-up. As each measurement file contains both data and set-up, set-ups can also be stored on and recalled from disk.

Calibration

When a system consisting of an analyzer and transducer(s) is to be calibrated, a reference source can be used to apply a known calibration level to the transducer(s). An autocalibration feature automatically adjusts the sensitivity of the input channels so that the displayed results correspond to the calibration level of the reference source.

If no reference source is available and the sensitivities of the transducers are known from their calibration charts, an approximate calibration is possible by entering the sensitivities directly into the Calibration menu (Fig. 8).

Types 2144 and 2148/7667 offer simultaneous calibration of both channels. Furthermore, the sensitivities to sound intensity and particle velocity can be verified. For this, a special coupler, such as that included in Brüel & Kjær Sound Intensity Calibrator Type 3541, must be used.

dB reference values and units can be keyed-in from the front panel of the analyzer for fast and easy calibration of, for example, hydrophones.

Pressure-Residual Intensity Index (2144, 2148/7667)

Sound Intensity Calibrator Type 3541 also allows the pressure-residual intensity index of the measurement system (microphones, preamplifiers and analyzer inputs) to be measured. Fig. 9 shows an example of the pressure-residual intensity index measured with Sound Intensity Probe Type 3548 (Type 4181 phase-matched microphones).

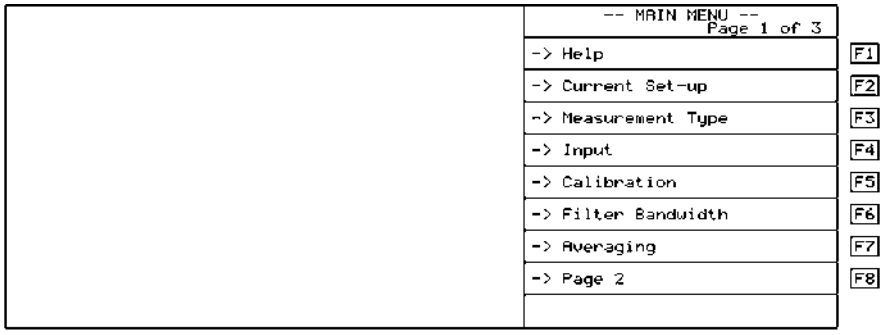

Fig.5 First page of the Main menu

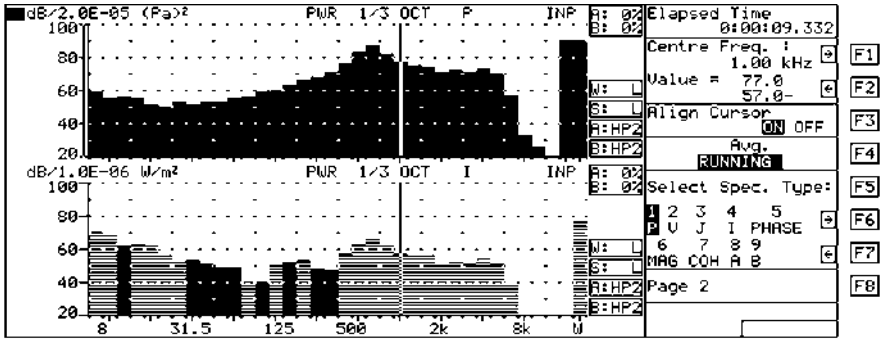

Fig.6 A typical 2144, 2148/7667 display in Measurement Mode

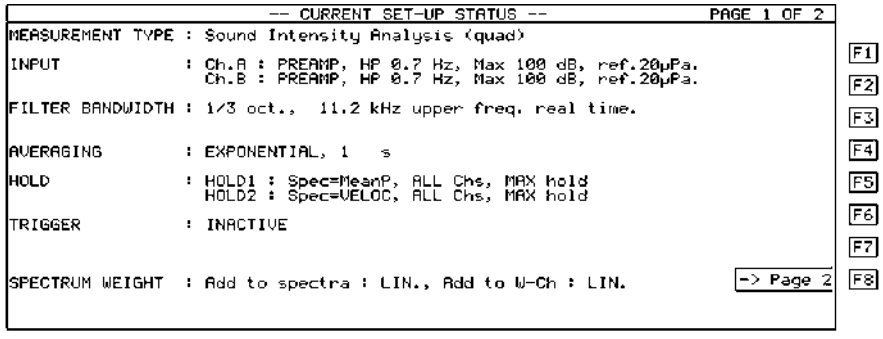

Fig.7 An overview of the Current Set-up (2144, 2148/7667)

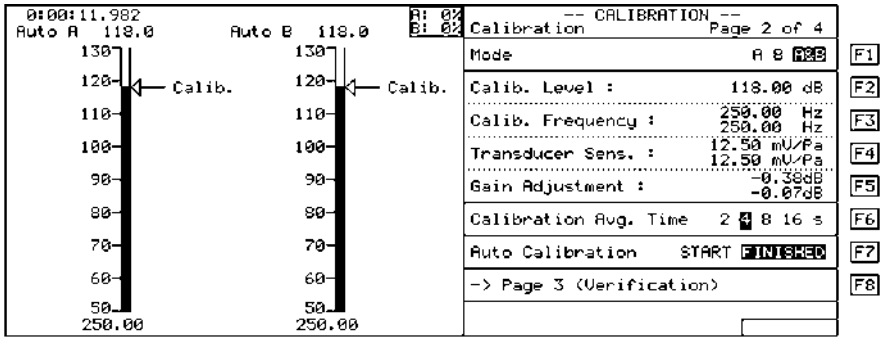

Fig.8 2144, 2148/7667 display after completion of an autocalibration

Measurement Types

The analyzers offer the following Measurement Types:

- **1 Ch. Autospectrum Analysis:** A-channel autospectrum is measured).
- **2 Ch. Autospectrum Analysis:** A- and B-channel autospectra are measured simultaneously.
- **Sound Intensity Analysis (2144, 2148/7667 only):** Active and reactive intensity, mean pressure, and particle velocity are

measured simultaneously. This means that all information about the sound field in one particular direction is captured in a single measurement. Furthermore, it allows calculation of A- and B-channel autospectra, phase spectra, and coherence spectra.

- **Cross Spectrum Analysis (2144, 2148/7667 only):** A- and B-channel autospectra with real and imaginary part of the cross spectrum are measured simultaneously. This makes it possible to calculate phase and coherence spectra as well as three frequency response functions (H1, H2, and H3) in real-time.

Averaging

Exponential or linear averaging are available, with selectable averaging times. Averaging is controlled by manual operation of the ⟨**Start**⟩, ⟨**Proceed**⟩ and ⟨**Stop**⟩ keys. Averaging times available depend on the selected bandwidth and whether the analyzer is in single or dual channel mode. For single channel $^1/_3$-octave analysis, the ranges are 1 ms to 24 hrs for linear averaging and $^1/_{512}$ s to 512 s in a binary sequence for exponential averaging. For dual channel analysis, the minimum averaging times are doubled.

Maximum and Minimum Hold

Maximum or minimum levels that occur during real-time measurements san be held on the display while a measurement progresses and can then be saved as the measurement result. The Maximum Hold or Minimum Hold condition can be applied to one or all frequency bands, or to any one of the A/L- or W-channels. Two different hold functions can be specified and used at the same time.

Data Exclude

The Data Exclude function is used to exclude unwanted noise events (for example a door slamming) from a measurement result. When a push-key is pressed during a measurement, the elapsed time counter is rounded down to the nearest multiple of 5 seconds and all data within the "ignore time" preceding the key-press is deleted from the measurement. The total measurement time automatically extends to compensate for the ignore time. Ignore time can be expanded to up to 10, 15 or 20 seconds by pressing the soft key up to four times in succession. The Data Exclude function is applicable in single spectrum real-time analysis.

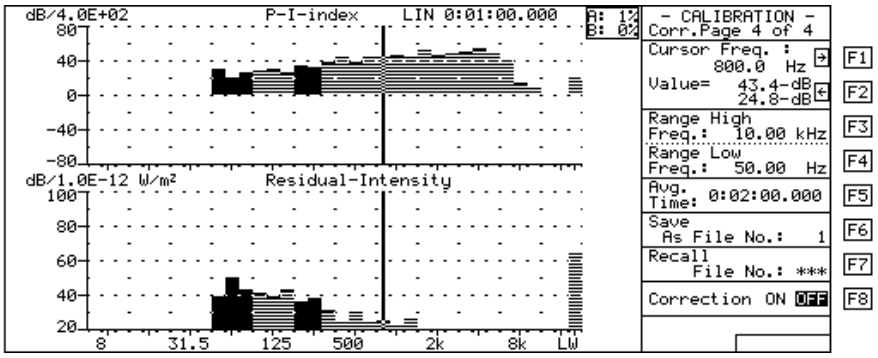

Fig.9 Typical Pressure–Residual Intensity Index of a Type 2144 analyzer and a Sound Intensity Probe Type 3548, measured according to IEC 1043 using Type 3541

Multispectrum and Slice

A multispectrum is a number of spectra stored in succession in the same file. This file can be viewed from two angles, either from the "front" where the spectra can be flicked through one after another, or from the "side" where each frequency band is viewed individually as a function of spectrum number; this is called a "slice" (Fig. 10). The analyzers operate with three types of multispectra:

Normal Multispectrum: Spectra can be recorded as a function of time, for example for measurements of impulse noise, or they can represent geometrical points when measuring sound power. The recording rate is up to 1000 spectra/second (single channel operation).

Gated Multispectrum: Allows multispectra from successive trigger cycles to be averaged into a single multispectrum. The number of averaged multispectra equals the number of triggers.

Gated measurements are normally used for measuring noise from rotating machines or other repetitive noise.

Fig. 11 shows the gating principle in one trigger cycle. The "gate" opens after a user-specified trigger delay (positive only) has elapsed. One spectrum is measured while the gate is open. As the gate closes, the spectrum is saved in an accumulator. The open-close-save sequence is then repeated for all spectra in the trigger cycle forming one multispectrum.

Matrix Multispectrum (2144, 2148/7667): Matrix Multispectrum is a part of the Trigger Multimode menu of Types 2144 and 2148/7667 (see Fig. 12). It allows the spectra in a multispectrum to be arranged in a row-column-direction system. This serves two purposes: one is to ease the overview of measurements, the other is to make sound intensity data compatible with computer programs and Brüel & Kjær laboratory analyzers (for example Type 2133) so that sound power determination and other data processing can be made.

Multispectrum Trigger

The following trigger conditions can be applied to the start of averaging when collecting a multispectrum:

Free Run: The measurement defined by the current set-up is continually repeated after **Averaging** ⟨**Start**⟩ is pressed.

Manual: The ⟨**Manual**⟩ key triggers a measurement as defined by the current set-up. This is often used for sound intensity measurements with Matrix Multispectrum.

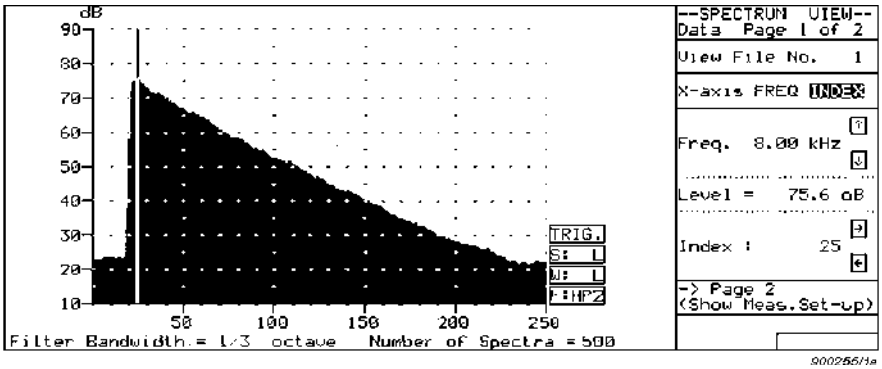

Fig.10 Arrangement of a multispectrum. "Slice" display at 8 kHz

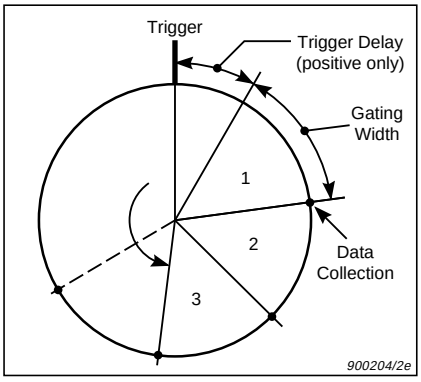

Fig.11 Gated measurement cycle

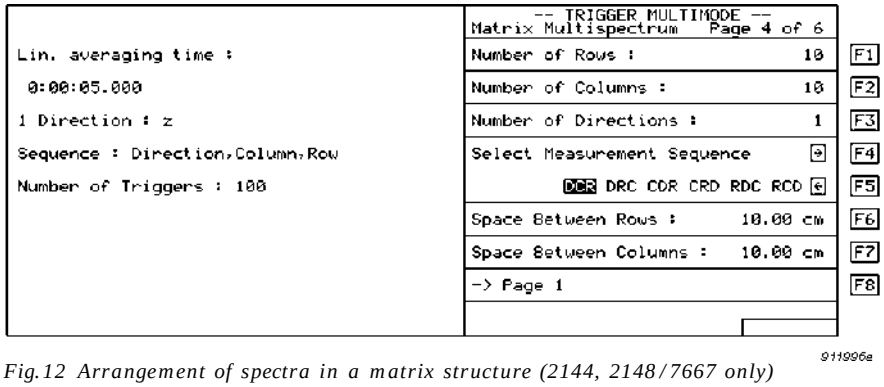

Fig.12 Arrangement of spectra in a matrix structure (2144, 2148/7667 only)

Time: Measurement begins at a time specified by the user. A fixed repetition interval can be set where required.

Internal: Measurement begins when a specified trigger level is exceeded (positive-slope trigger) or fallen below (negative-slope trigger) in either a specified frequency band or in one of the channels displaying the broadband weighted or non-weighted spectrum level. Types 2144 and 2148/7667 allow internal triggering on several Spectrum Types, for example intensity spectra or cross spectra. Internal triggering is used, for example, for pistol-shot reverberation measurements.

External: Measurement begins on the arrival of an external trigger signal at the Trigger Input socket on the back panel of the analyzer. This is often used for tacho-probe input with Gated Multispectrum, or for run-up/coast-down measurements with Normal Multispectrum.

Pre- and Post-trigger Delay

The user-defined post-trigger delay (0 to 5000 s depending on set-up) can be used to delay the start of averaging for a fixed period after the trigger conditions have been met. Alternatively, entering negative values for the post-trigger delay results in a pre-trigger delay. Pre-trigger delay enables spectra monitored prior to the trigger conditions being met to be included as part of the measurement result. The maximum pre-trigger delay is 34 spectra for $^1/_3$-octave measurements.

When the selected triggering conditions are satisfied and the delay has elapsed, the analyzer starts to collect the multispectrum defined by the Trigger Multimode menu. Fig. 13 shows an example of the set-up for a normal multispectrum measurement. Pre-trigger delay is set to 5 seconds corresponding to 10 spectra.

Taktmaximal

Taktmaximal noise measurements can be made according to TA lärm. Taktmaximal modes Averaging or Spectra can be selected. In Averaging mode all the spectra specified are averaged to one spectrum. Spectra mode stores all spectra as a multispectrum. The Takt Duration can be set to 3, 5 or 30 seconds.

Boom and Multiplexer

Connectors on the back panel allow remote control of Sound Source Type 4224 and either Rotating Microphone Boom Type 3923 or Multiplexer Type 2811 or 2822. A special Boom and Mux menu is used for setting the analyzer up for building acoustics measurements: sound pressure level in source room and receiving room, background noise, impact level and reverberation time. Fig. 14 shows the menu page for setting up parameters for a reverberation time data collection.

Autosequence

A pushkey autosequence facility provides full automation of measurements. The analyzer's internal memory can hold four different autosequences, each consisting of up to 200 keypushes. An autosequence may include any procedure that can be performed manually by using the hard and soft keys on the front panel of the analyzer.

A "countdown-to-start" can be set so that the execution of an autosequence is delayed after the start signal is given. One application of this delay is to allow an operator time to leave the measurement area before the start of measurements. Another application is to allow the analog circuits to stabilize after "Wake-up" (see below).

Standby/Wake-up Mode

For applications where an autosequence is required to be executed without the presence of an operator, the analyzer features a special Wake-up Mode. In this low-power mode, all functions except the internal real-time clock are switched off. Wake-up Mode is indicated by a flashing **Standby** LED on the front-panel of the analyzer.

At a user-defined "Wake-up time", all functions switch on again and the analyzer executes a previously selected autosequence. If a measurement needs to be repeated, a "Number of Wake-ups" and a "Wake-up Interval" can be specified.

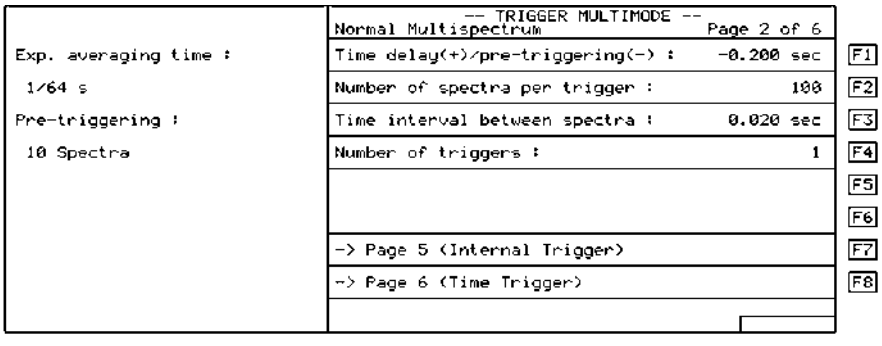

Fig.13 Menu for defining a normal multispectrum

Data Storage

Spectrum Memory

The spectrum memory is the part of the memory allocated for storage of measured data. The number of spectra that the spectrum memory can hold depends on the selected filter bandwidth, frequency range and, for Types 2144 and 2148/7667, the Measurement Type. The following shows as an example the number of spectra that the memory can hold, measured with the maximum real-time frequency range:

2143 (autospectra):

Bandwidth	Number of Spectra
$^1/_1$-octave	4736
$^1/_3$-octave	2841
$^1/_{12}$-octave	1136
$^1/_{24}$-octave	660

2144, 2148/7667 (sound intensity spectra):

Bandwidth	Number of Spectra
$^1/_1$-octave	1198
$^1/_3$-octave	538
$^1/_{12}$-octave	177
$^1/_{24}$-octave	98

Spectra are saved individually or as multispectra in up to 111 files which are transferable to disk memory.

Spectrum Recording Rate

The analyzers can record spectra at intervals down to 1 ms with no loss of data (no "gaps" between measurements). This maximum rate is obtained with single channel, real-time operation. In general, the recording rate depends on the chosen Measurement Type, filter bandwidth, frequency range and, if linear averaging has been selected, the linear averaging time.

Disk-drive

The built-in $3\,^1/_2$″ high density disk-drive can be used for permanent storage of spectra. Results saved in the spectrum memory of the analyzer can be transferred directly onto disk and a list of the files already on disk can be viewed at any time. Formatted disks are compatible with PC/MS–DOS and the analyzers are, therefore, powerful data-gathering devices. For processing on Real-time Frequency Analyzers Types 2123 and 2133, data must be stored on double density disks.

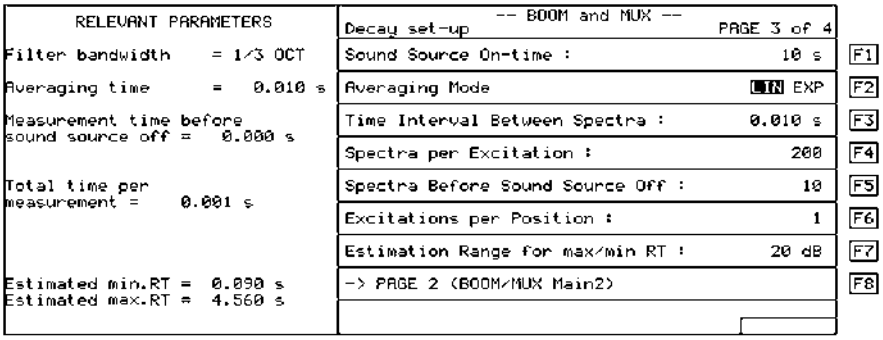

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Fig.14 Example of set-up for reverberation time data collection (2144, 2148/7667)

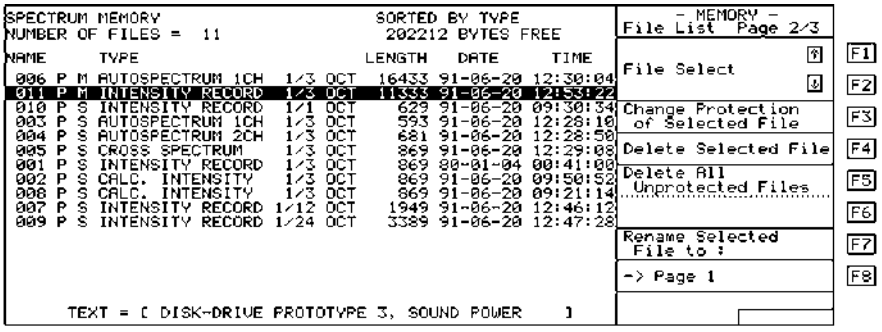

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Fig.15 List of files in the spectrum memory (2144, 2148/7667)

Measurement Text

Each file can be labelled with up to 40 characters of text. When a file is selected, the corresponding file-text is shown at the bottom of the screen display. Files can be sorted in the file list, by name (number), time, length, or type. "Type" classifies the spectra into groups according to: filter bandwidth, Measurement Type, whether they were measured or calculated, and whether they are single spectra or multispectra. Fig. 15 shows an example of a file list. Text is added to the selected file to aid identification.

Post-processing

The analyzers are mainly intended as data *gathering* devices. However, they also have some data *processing* facilities. Some of these facilities function in real-time and some can be applied to recalled spectra.

Sound Power Calculation (2144, 2148/7667)

Types 2144 and 2148/7667 allow sound power to be calculated on the basis of SPL or intensity measurements. Data must be arranged in a multispectrum. The calculation is made simply by entering the physical size of the enclosing area (see Fig. 16).

Spectrum Arithmetic

The Spectrum Calculator menu is used for arithmetic operations on spectra recalled from memory. Spectra that were measured using different filter bandwidths are made compatible for calculations by automatic conversion to the user-selected "working bandwidth".

The arithmetic basis for spectrum additions and subtractions can be selected as either "dB" (for which 50 dB plus 50 dB equals 100 dB) or as "absolute power" for which dB units are first converted to absolute power units for the arithmetic operation and then converted back to dB for the final answer (50 dB plus 50 dB equals 53 dB).

"dB" arithmetic is typically used for adding/subtracting single number constants or weighting corrections to/from spectra. "Absolute power" arithmetic is for adding and subtracting spectra or background noise spectra.

Integration and Differentiation

The input spectrum can be integrated or differentiated once or twice. This is purely digital real-time processing. Integration is used for obtaining a vibration velocity spectrum from an accelerometer measurement.

Spectrum Unit

The spectrum unit is calculated in real-time. There is a choice of five

different spectrum units for an input spectrum:

PWR: Power (Mean Square)
RMS: Root Mean Square
ENG: Energy (time integral of PWR)
ESD: Energy Spectral Density (ENG divided by bandwidth)
PSD: Power Spectral Density (PWR divided by bandwidth)
Power (PWR) is the normal output from the RMS-processor.

Digital Spectrum Weighting
The Spectrum Weighting menu is used for adding user-defined weightings or standard A-, B-, C-, and D-weightings to input spectra (real-time) or to spectra recalled from the memory. User-defined weightings are entered as a series of points, with the analyzer interpolating between the points to produce the complete weighting function, or they can be based on measured data. A total of four user-defined weightings can be saved in the non-volatile internal memory. User-defined weightings can be used, for example, to mask unwanted frequency components.

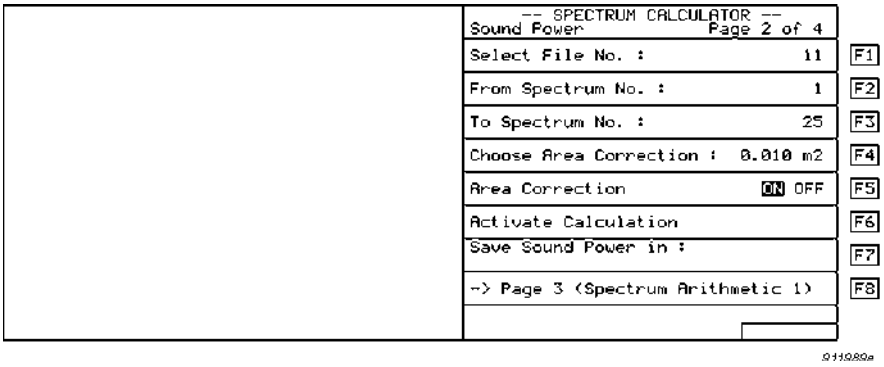

Fig.16 The Spectrum Calculator menu is used for sound power calculations (2144, 2148/7667 only) and spectrum arithmetic

Application Programs

The modular construction of Types 2143 and 2144 ensures high versatility and allows the analyzers to be used not only as digital-filter analyzers, but as "2-in-1" analyzers where an application program is loaded from disk. In this way, the whole configuration of the analyzer can easily be changed. The following application programs are available.

Type 7638 — Zwicker Loudness Option: Allows real-time measurement of the loudness of impulsive (non-stationary) noise. The loudness calculation is based on ISO 532 B and also simulates the post-masking properties of the ear. See Product Data sheet BP 1006.

Type 7651 — Dual Channel FFT Option for Type 2144: Turns Type 2144 into a dual channel FFT analyzer equivalent to Type 2148. It has up to 800 lines resolution and a dual channel real-time rate up to 25.6 kHz ($^1/_3$ overlap). Real-time zoom, cross and intensity spectra, frequency response functions. A separate Product Data sheet is available (BP 1285). This software can also be used with Type 2143, but without cross-functions.

Computer Software

WT 9366 — Calculation of Reverberation Time: For calculation of reverberation times using measurements made on Type 2143 and 2144 loaded with Type 7666 or 7667 software. A stand alone program or can be installed as a module for Utility Program Type 5306.

WT 9367 — Ln Calculation Software: The program is able to make cumulative distribution calculations on spectrum files from Analyzers Types 2143 and 2144 loaded with Type 7666 or 7667 software. A stand alone program or can be installed as a module for Utility Program Type 5306.

WT 9378 — Sound Intensity Program: For mapping intensity data. 3D, contour, numeric, and sector-ranking plots. A separate System Development sheet is available (BU 0131).

Type 5304 — Sound Power Program: Standardized sound power software for Type 2144 and 2148/7667. Controls a complete measurement system and makes calculations of sound power using the sound intensity method. The software runs under Windows on a laptop computer.

Type 5305 — Building Acoustics Program: For calculation of airborne and impact sound insulation plus reverberation time according to the international standards ISO 140 and ISO 3382, and several national standards. See Product Data sheet BP 1401.

Type 5306 — Utility Program: For the entire 2140 family of portable analyzers. Displays spectra from the analyzer on a computer screen and enables hard copies of the data. WH 3075 can be added for generating 3 D and contour plots.

Type 7679 — Sound Power Program: For determination of sound power according to ISO 9614–2, ECMA 160 (engineering grade) and ANSI S 12–12, using sound intensity measurements made with Type 2144. See Product Data sheet BP 1432.

Type 7680 — Sound Power Program: For determination of sound power from sound pressure measurements according to ISO 3741, 3743, 3744 and 3745. A seperate Product Data sheet is available (BP 1430).

Type 7681 — Noise Source Location Program: For location of noise components emitted from a noise source using pressure and intensity measurements made with Type 2144. A seperate Product Data sheet is available (BP 1443).

Specifications 2143, 2144, 2148/7667

Input Characteristics

All inputs pseudo difference. Choice of analogue ground floating or connected to chassis. Individual set-up for each channel

PREAMPLIFIER INPUT:

Pseudo Difference Input: Two 7-pin Preamplifier sockets or one 18-pin socket (for sound intensity probes)

Input impedance (signal to signal ground): 1 MΩ || 100 pF

Signal ground to analogue ground impedance: 50 Ω || 10 nF

Input ranges: Twelve 80 dB ranges with a FSD from 10 mV to 3.16 V (rms sine) selectable in steps of 5 dB

Frequency Range: 0.7 Hz to 22.4 kHz, ±0.1 dB

Noise: 1µV, measured in 1/3-octave bands in input range 10 mV with input short-circuited

Microphone polarization: 0 V, 28 V, 200 V from 10 MΩ source

Power supply: 28 V

Heater Voltage: None

High-pass filter cut-offs:

−0.1 dB at 0.7 Hz (−3 dB at 59 mHz).
Slope 6 dB/octave
−0.1 dB at 20 Hz (−3 dB at 6.6 Hz).
Slope 12 dB/octave
−0.1 dB at 100 Hz (−3 dB at 33 Hz).
Slope 12 dB/octave

A-filter: According to IEC publication 651 type 0

DIRECT INPUT:

Pseudo Difference Input: Two BNC sockets (via preamplifier-to-BNC adaptors)

Input impedance (signal to signal ground): 1 MΩ || 100 pF

Signal ground to analogue ground impedance: 50 Ω || 10 nF

Input ranges: Twelve 80 dB ranges with a FSD from 10 mV to 3.16 V (rms sine) selectable in steps of 5 dB

Frequency Range: 0.7 Hz to 22.4 kHz, ±0.1 dB

Noise: 1µV, measured in 1/3-octave bands in input range 10 mV with input short-circuited

High-pass filter cut-offs:

−0.1 dB at 0.7 Hz (−3 dB at 59 mHz).
Slope 6 dB/octave
−0.1 dB at 20 Hz (−3 dB at 6.6 Hz).
Slope 12 dB/octave
−0.1 dB at 100 Hz (−3 dB at 33 Hz).
Slope 12 dB/octave

A-filter: According to IEC publication 651 type 0

ACCELEROMETER INPUT:

Pseudo Difference Input: Two micro connectors, 10–32 UNF

Input impedance (signal to signal ground): 39 Ω || 220 pF

Signal ground to analogue ground impedance: 50 Ω || 10 nF

Input ranges: Eighteen 80 dB ranges with a FSD from 1pC to 17.8 nC (rms sine) selectable in steps of 5 dB

Frequency Range: 0.35 Hz to 22.4 kHz, ±0.1 dB

Noise: Measured in 1/3-octave bands in input range 1pC with 1nF transducer capacitance:

0.35 Hz to 35 Hz:	< 3 fC
35 Hz to 2.8 kHz:	< 0.5 fC
2.8 kHz to 8.9 kHz:	< 1 fC
8.9 kHz to 22.4 kHz:	< 1.5 fC

High-pass filters cut-off:

−0.1 dB at 0.35 Hz (−3 dB at 50 mHz).
Slope 6 dB/octave
−0.1 dB at 20 Hz (−3 dB at 6.6 Hz).
Slope 12 dB/octave
−0.1 dB at 100 Hz (−3 dB at 33 Hz).
Slope 12 dB/octave

CHANNEL–TO–CHANNEL MATCH:

Max. Gain Difference: 0.1 dB from lower frequency limit to upper frequency limit (in passband)

Max. phase difference for preamplifier and direct input:

50 Hz to 315 Hz:	<0.017°
315 Hz to 630 Hz:	<0.021°
630 Hz to 1.25 kHz:	<0.042°
1.25 kHz to 2.5 kHz:	<0.083°
2.5 kHz to 5 kHz:	<0.166°
5 kHz to 15 kHz:	<0.333°

MAXIMUM RATINGS:

Input:

Preamplifier & Direct: 7.5 V peak, 50 V DC.
Accelerometer: 33 nC peak

Signal Ground/Chassis Ground: For safe operation in accordance with IEC 1010, the voltage between signal ground and chassis ground (in "floating" mode) must not exceed 42 V RMS. To ensure safe operation in accordance with IEC 1010 at higher voltages, the user must limit all input currents to 0.7 mA peak

Signal Ground/Analogue Ground: 5 V peak. If this limit is exceeded, the user must limit the ground current to 50 mA. If the voltage exceeds 1 V peak, the dynamic range is decreased

MAX. INDUCED COMMON MODE VOLTAGE: 42 V RMS, 100 V peak

COMMON MODE REJECTION:

Floating input, 50 Ω source impedance:

0.35 Hz to 1 kHz:	> 75 dB
1 kHz to 22.4 kHz:	> 50 dB

DIFFERENTIAL COMMON MODE REJECTION:

50 Ω source impedance: DC to 250 Hz > 35 dB

OVERLOAD DETECTION:

Both analogue and A/D-converter overloads indicated.

CROSSTALK:

−60 dB

ATTENUATOR LINEARITY:

±0.1 dB

ANTIALIASING FILTER:

Cut-off frequency: 30 kHz (single channel), 15 kHz (dual channel). Provides at least 80 dB attenuation of those input frequencies which can cause aliasing in the pass-band

SAMPLING RATE:

1 × 65536 Hz or 2 × 32768 Hz

A/D-CONVERSION:

Resolution: 16 bit

Quantizing Error: Maximum 1/2 LSB

Digital Filters

1/1-OCTAVE FILTERS:

14-pole filters with centre frequencies given by $10^{3\,n/10}$. Fulfil IEC 225-1966, DIN 45651 and ANSI S1.11-1986, Order 7 Type 1-D, optional range

Single Channel: $-1 \le n \le 14$. 16 filters with centre frequencies from 0.5 Hz to 16 kHz

Dual Channel: $-1 \le n \le 13$. 15 filters with centre frequencies from 0.5 Hz to 8 kHz

1/3-OCTAVE FILTERS:

6-pole filters with centre frequencies given by $10^{n/10}$. Fulfil IEC 225-1966, DIN 45651 and ANSI S1.11-1986, Order 3 Type 1-D

Single Channel: $-4 \le n \le 43$. 48 filters with centre frequencies from 0.4 Hz to 20 kHz

Dual Channel: $-4 \le n \le 40$. 45 filters with centre frequencies from 0.4 Hz to 10 kHz

1/12-OCTAVE FILTERS:

6-pole filters with centre frequencies given by $10^{(n\,+\,0.5)/40}$

Single Channel: $-18 \le n \le 173$. All 192 filters with centre frequencies from 0.365 Hz to 21.752 kHz can be measured in a four-pass mode, or 168 filters from 0.365 kHz to 5.464 kHz can be shown in real-time

Dual Channel: $-18 \le n \le 161$. All 180 filters with centre frequencies from 0.365 Hz to 10.902 kHz can be measured in a four-pass mode, or 156 filters from 0.365 kHz to 2.738 kHz can be shown in real-time

1/24-OCTAVE FILTERS:

6-pole filters with centre frequencies given by $10^{(n\,+\,0.5)/80}$

Single Channel: $-36 \le n \le 347$. All 384 filters with centre frequencies from 0.360 Hz to 22.067 kHz can be measured in an eight-pass mode, or 312 filters from 0.360 Hz to 2.778 kHz can be shown in real-time

Dual Channel: $-36 \le n \le 323$. All 342 filters with centre frequencies from 0.360 Hz to 11.060 kHz can be measured in an eight-pass mode, or 288 filters from 0.360 Hz to 1.392 kHz can be shown in real-time

BROADBAND FILTERS:

Two broadband channels, labelled "L" and "W", are associated each input channel ("A" or "B").

L-Channel: Represents broadband level of the input signal (A-weighted or unweighted)

W-Channel: Represents broadband level of the measured spectrum, possibly post-weighted with A,B,C or D standard curves or user-defined (or Spacer-dependent weighting if in intensity mode)

System Accuracy

DYNAMIC RANGE:

All distortion (intermodulation and harmonic) and spurious noise at least 80 dB below max. input voltage for 1/3-octave autospectrum

OVERALL FREQUENCY RESPONSE:

±0.1 dB at filter centres from lower frequency limit to upper frequency limit
(See Input Characteristics for frequency limits)

NOISE:

Voltage input: Measured in 1/3-octave bands in input range 10 mV with input short-circuited: 0.7 Hz to 22.4 kHz < 1µV

Charge input: Measured in 1/3-octave bands in input range 1 pC with 1 nF transducer capacitance:

0.35 Hz to 35 Hz:	< 3 fC
35 Hz to 2.8 kHz:	< 0.5 fC
2.8 kHz to 8.9 kHz:	< 1 fC
8.9 kHz to 22.4 kHz:	< 1.5 fC

AMPLITUDE MEASUREMENT STABILITY:

±0.1 dB

AMPLITUDE LINEARITY:

±0.05 dB or ±0.005% of max. input voltage, whichever is greater, measured using sine wave input at the filter centre frequency. With measurements more than 60 dB below max. input voltage, the measuring sine wave is accompanied by another sine wave of a lower frequency outside the measured band, having an amplitude greater than 20 dB below max. input voltage

FREQUENCY ACCURACY AND STABILITY:

0.01% without warm-up (no adjustment needed)

Detectors

Digital true RMS detection of filter bank and two broadband channels. No crest factor limitation

CONTROL:

Start: Clears the average accumulator and starts an average

Stop: Stops the averaging process

Proceed: Continues an average without clearing the average accumulator

Averaging Gate: External or internal trigger signal for gating of the averaging process

Start conditions: Free Run, Manual, External, Absolute Time, or Internal triggering at a specified level with selectable slope

Delay: Pre- and post-trigger delay between start condition and actual multispectrum start, set in seconds

Multispectrum update rate: From 1ms (2ms for dual channel) to 24hours; 1ms resolution

Averaging

LINEAR:

Averaging without truncation.

Single Channel: Averaging times from 1ms to 24 hours selectable to a resolution of 1ms in the range 1ms to 1hr and to 1s in the range 1hr to 24 hours

Dual Channel: Averaging times from 2ms to 24 hours selectable to a resolution of 2ms in the range 2ms to 1hr and to 1s in the range 1hr to 24hours

EXPONENTIAL:

Single Channel: 19 averaging times from 1/512s to 512s in a binary sequence

Dual Channel: 18 averaging times from 1/256s to 512s in a binary sequence. "Fast" and "Slow" (1/4s and 2s) sound level meter responses according to IEC 651 type 0

Spectrum Memory

Non-volatile internal memory for 111 single spectrum or multispectrum files each labelled with up to 40 characters of user-defined text. The text label is stored together with data and is shown in the file list

Control: Manual save or multispectrum automatic save

Max. no. of spectra: 2457 for single channel octave autospectra or 1474 for 1/3-octave

Max. (or Min.) hold, all bands: Composite spectrum of max. (or min.) RMS level occurring in each channel

Max. (or Min.) hold, specified band: Retains the spectrum for which max. (or min.) RMS level has occurred in the specified band

Mass Storage

Built-in disk-drive for storage of measured data and optional programs

Data media: Removable $3\,^1/_2''$ double sided, high density micro floppy disk

Data format: Compatible with PC/MS-DOS from version 3.2. PC-DOS is a trademark of International Business Machines Corporation. MS-DOS is a trademark of Microsoft Corporation

Formatted capacity: 1440 kbytes

File list: Contains disk identification, user-definable volume label and file list sorting key. Each file is identified by user-definable file number, data type, size and measurement start time

Hard Copy

Graphics printer: Any display on Type 2143, including graphics and all notation, can be printed on graphics printers with IBM, HP or Epson print formats or on Brüel & Kjær Graphics Recorder Type 2313

Autosequence

Allows the user to specify an autosequence of front panel keypushes, the functions of which can be executed on command. Maximum 200 key entries per autosequence. Up to 4 autosequences can be saved in non-volatile memory

Display

Liquid Crystal Display (dot matrix, super twisted nematic) with back-light and resolution 480 × 200 points

DISPLAY FORMATS:

Single: A single spectrum showing pressure, acceleration, intensity, particle velocity, phase, and coherence. Digital integration or differentiation of spectrum is possible

Dual: Two spectra (two input spectra or input spectrum and recalled spectrum) displayed in upper and lower parts of the display, respectively

Difference: Two spectra. The upper is the difference and the lower is the recalled

Slice: A time slice through a multispectrum

Menu: The text shown relates to the soft key control

Y-AXIS:

Annotation: Absolute units or relative units (dB). Selectable dB reference

Calibration: Pressure, acceleration. Verification of particle velocity, active and reactive intensity. Measurement of pressure-residual intensity index. Direct entry of transducer sensitivity or autocalibration with an appropriate calibrator. Direct entry of dB reference

Spectrum type: RMS, power, power spectral density, energy spectral density or energy

Amplitude scroll: Hard key controls to shift the display up and down.

X-AXIS:

Spectrum display: Logarithmic axis with annotation in Hz at 1/1-octave centre frequencies conforming with ISO R266. Range from 1 to 16 octaves. 11 octaves at a time can be shown on the display

Frequency scroll: Hard key controls to shift the display left and right

Slice display: Linear axis annotated from with index numbers from 1 up to a maximum of 999 (representing time, points, etc.)

CURSOR:

Reads frequency in Hz on the x-axis (spectrum display) or index number (slice display) and at the same time reads amplitude level in dB or absolute units and phase in degrees on the y-axis

Operation

Menus: User-interactive menus are used to set-up the analyzer for measurements. 4 user-defined measurement set-ups can be saved and recalled from non-volatile internal memory

Measurement mode: Enables measurements

Spectrum view: For looking at spectra and slices in the internal non-volatile memory

Help pages: Each user-interactive menu is provided with a corresponding page of help text

IEC/IEEE Interface

Conforms to IEEE–488.1 and IEC 625-1 standards. Any function shown on display (including measured data, post-processed result, measurement set-up, display set-up or calibration set-up) can be transmitted to and from the analyzer

FUNCTIONS IMPLEMENTED:

Source Handshake	SH1
Acceptor Handshake	AH1
Talker	T5
Listener	L3
Service Request	SR1
Remote/Local	RL1
Parallel Poll	PP1
Device Clear	DC1
Device Trigger	DT1

COMMAND SET:

Simple and easy to remember standard engineering English. Resistant to operator error

CODE:

ASCII (ISO 7-bit) code, or binary

INTERFACE TERMINATOR:

Can be specified on the Interface Menu

DEVICE ADDRESS:

Can be specified on the Interface menu

RS–232 Interface

Conforms with the EIA Standard RS–232 (equivalent to CCITT V 24). Allows remote activation of the front panel key functions via a non-intelligent terminal, either directly or via a modem

Input/Output

Trigger Input: BNC connector for external trigger to start an average instantaneously or with user-defined delay

Remote Control: Two 8-pin DIN sockets for remote control of Rotating Microphone Boom Type 3923 or Multiplexer Type 2811 or 2822. Two 8-pin DIN sockets for remote control of Sound Source Type 4224. 18-pin socket for connection of Intensity Probe Type 3584

Power Supply

Battery: 6 rechargeable NiCd cells (QB 0008) operate the system for > 4 hrs continuous use at 25°C. The operating time is reduced if disk-drive or interface bus is used and decreases with decreasing temperature.

COMPLIANCE WITH STANDARDS:

CE	CE-mark indicates compliance with: EMC Directive and Low Voltage Directive.
Safety	EN 61010–1: Safety requirements for electrical equipment for measurement, control and laboratory use.
EMC Emission	EN 50081–1: Generic emission standard. Residential, commercial and light industry. EN 50081–2: Generic emission standard. Industrial environment. CISPR 22: Radio disturbance characteristics of information technology equipment. Class B Limits. FCC Rules, Part 15: Complies with the limits for a Class B digital device.
EMC Immunity	EN 50082–1: Generic immunity standard. Residential, commercial and light industry. EN 50082–2: Generic immunity standard. Industrial environment. **Note:** See "EMC".
Temperature	IEC 68–2–1 & IEC 68–2–2: Environmental Testing. Cold and Dry Heat. Operating Temperature (Analyzer): –10 to +55°C (+14 to +131°F) Operating Temperature (Disk drive): –5 to +50°C (+23 to +122°F) Storage Temperature: –25 to +70°C (–13 to +158°F)
Humidity	IEC 68–2–3: Damp Heat: 90% RH (non-condensing at 40°C (104°F))
Mechanical	Non-operating: IEC 68–2–6: Vibration: 0.3 mm, 20 m/s^2, 10–500 Hz IEC 68–2–27: Shock: 1000 m/s^2 IEC 68–2–29: Bump: 1000 bumps at 250 m/s^2
Enclosure	IEC 529: Protection provided by enclosures: IP 43

Mains: An external source or filtered DC power in the range of 11–16 V DC will power the analyzer continuously. The Brüel & Kjær Power Supply ZG 0342 fits into the slot normally occupied by the battery pack and is powered from 90 to 264 V AC mains supply
Power Consumption: 900 mA during measurements at a typical battery drive-voltage of 7.5 V (back lighting off)

EMC

SUSCEPTIBILITY TO DISTURBANCES SPECIFIED IN EN 50082–2:
Measured with floating input module.

LF Magnetic Field: (30 A/m at 50 Hz)

Input/Output	Level
Preamp., Probe Direct via Preamp.[1]	< 10 µV
Charge[2]	< 1 fC

Radiated RF: (3 to 10 V/m, 80% AM, 1 kHz)

Input/Output	Level
Preamp., Probe Direct via Preamp.[1]	< 25 µV
Charge[2]	< 2 fC

Conducted RF: (3 to 10 V, 80% AM, 1 kHz)

Input/Output	Level
Preamp., Probe Direct via Preamp.[1]	< 1 µV
Charge[2]	< 16 fC

[1] Input section with max. gain and input short-circuited
[2] Input section with max. gain and 1 nF termination

Cabinet

DIMENSIONS:
Height: 175 mm (6.89″)
Width: 356 mm (14.02″)
Depth: 293.5 mm (11.56″)
Weight: 9.3 kg (20.46 lb.)

Ordering Information

Types 2143 and **2144**: Real-time Frequency Analyzers
Include the following accessories:

ZG 0342	Power Supply
AQ 0035:	7-core DIN Cable (1.5 m)
ZG 0146:	Battery Box
6×QB 0008:	1.25V NiCd Batteries, type R 20 (“D” size)
JP 0312:	3-pin Plug
JP 0808:	8-pin DIN Plug
DH 0541:	Shoulder Strap
AQ 0157:	Charging Adaptor
2×AO 0479:	Lemo-to-BNC Adaptor
BZ 5048:	2 program disks VP 7234

Optional Accessories

TRANSDUCERS:

Type 3584:	Sound Intensity Probe (2144, 2148/7667)
Type 4190:	General-purpose 1/2″ Measuring Microphone
Type 2669:	Microphone Preamplifier
AO 0488:	Lemo to B&K Adaptor
Type 4371:	General-purpose Accelerometer

Brüel & Kjær supplies a wide range of microphones and accelerometers. Please ask for more information regarding the different types and their uses.

CALIBRATION:

Type 3541:	Sound Intensity Calibrator
Type 4204:	Reference Sound Source
Type 4226:	Multifunction Acoustic Calibrator
Type 4228:	Pistonphone
Type 4231:	Sound Level Calibrator
Type 4294:	Calibration Exciter

HARDWARE:

Type 2822:	Microphone Multiplexer, 12 channel
Type 3923:	Rotating Microphone Boom
Type 4224:	Sound Source

ENHANCEMENTS (2143):

WH 2921:	Memory Extension 1 Mb
WH 2924:	Memory Extension 0.5 Mb
UA 1350:	Kit for Upgrading to Type 2144

APPLICATION PROGRAMS:

Type 7638:	Zwicker Loudness Option
Type 7651:	Dual Channel FFT Option for Type 2144 (or Type 2143 without cross-functions)

COMPUTER SOFTWARE:

WT 9366:	Calculation of Reverberation Time
WT 9367:	Ln Calculation Software
WT 9378:	Mapping and Sound Power Program
Type 5304:	Sound Power Program
Type 5305:	Building Acoustic Program
Type 5306:	Utility Program for Types 2144, 2148
Type 7679:	Sound Power Program for Type 2144
Type 7680:	Sound Power Program
Type 7681:	Noise Source Location Program

INTERFACE:

AO 0195:	Adaptor to convert IEEE–488 connector to IEC 625-1 (25-way)
AO 0264:	Interface Cable (2 m), IEC 625-1 (25-way) to IEEE–488
AO 0265:	Interface Cable (2m), IEEE–488
UA 0814:	IEEE 24-way bus connector kit

MISCELLANEOUS:

QB 0008:	1.25V NiCd Battery, type R 20 (“D” size)
QR 1102:	10 Micro Floppy Disks (Double Density)
QR 1105:	10 Micro Floppy Disks (High Density)

Brüel & Kjær

WORLD HEADQUARTERS: DK-2850 Nærum • Denmark • Telephone: +4542800500 •Telex: 37316 bruka dk • Fax: +4542801405 • e-mail: info@bk.dk