Product Data

Real-time Frequency Analyzer — Type 2123

Dual Channel Real-time Frequency Analyzer — Type 2133

USES:

- ❍ Constant-percentage bandwidth frequency analysis of sound and vibration signals in real-time
- ❍ Measurement of sound power
- ❍ Sound intensity and pressure mapping
- ❍ Mapping of non-stationary signals
- ❍ Electroacoustic testing
- ❍ Building acoustics testing: sound transmission, absorption, reverberation time
- ❍ Automobile acoustic testing

FEATURES:

- ❍ $^{1}/_{1}$-, $^{1}/_{3}$-, $^{1}/_{12}$- or $^{1}/_{24}$-octave analysis
- ❍ Real-time $^{1}/_{3}$-octave analysis up to 22.4 kHz (single channel), 11.2 kHz (dual channel)
- ❍ PROM-based software for rapid start-up
- ❍ Inputs: preamplifier (microphone), accelerometer (charge), intensity probe, and direct
- ❍ 80 dB dynamic range, autoranging
- ❍ Internal mapping and sound power analysis
- ❍ Time-function capture, signal enhancement
- ❍ Built-in processing functions for sound power, sound insulation, reverberation time
- ❍ Data transfer from Real-time Frequency Analyzers Type 2143 and 2144
- ❍ Hard copy from graphics plotter, graphics printer, laser printer and colour printer
- ❍ Powerful mathematical language for fast user-defined data processing
- ❍ Storage of more than 2200 $^{1}/_{3}$-octave spectra
- ❍ $3^{1}/_{2}$″ floppy disk (PC/MS–DOS compatible)
- ❍ Pushkey autosequencing
- ❍ Acquisition and processing of arrays of spectra
- ❍ Internal generator for pink, white, random, and pseudorandom noise and noise-bursts
- ❍ Optional 80 kHz frequency range using ZT 0318

Types 2123 and 2133 allow fractional octave analysis in $^{1}/_{1}$-, $^{1}/_{3}$-, $^{1}/_{12}$- or $^{1}/_{24}$-octaves. Time functions can be recorded, and windowed portions of these functions frequency analyzed.

Extensive processing of data can be done within the analyzer using the pre- or user-defined mathematical functions. Multispectra, that is, arrays of spectra, can be stored in the analyzer's extensive memory, where they can then be manipulated as single units in the necessary calculations. Data can be displayed as time signals or spectra, or as landscape (3D), contour, number or vector maps. Spatial mapping allows sound source location and sound power determination, while sequential mapping can be used, for example, for analysis of run-up/coast-down measurements or periodic signals.

Type 2133 offers dual- and cross-channel functions, enabling measurement of sound intensity, both active and reactive, particle velocity, and the complex cross-spectrum.

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Real-time Frequency Analyzers Types 2123 and 2133 are designed for acoustics, electroacoustics and vibration measurements, and analyse in $^1/_1$-, $^1/_3$-, $^1/_{12}$- and $^1/_{24}$-octave bandwidths. They have a dynamic range of 80 dB, and fully instrumented high-quality analogue inputs which accept the full range of Brüel & Kjær microphones and preamplifiers. The built-in high-sensitivity charge preamplifier enables direct connection of accelerometers. A time capture function records transient events for later analysis, in whole or part. Measurement possibilities are extended by a rapid spectrum acquisition mode, and gated averaging.

Type 2123 is a single-channel analyzer. Type 2133 is a dual-channel version of the same analyzer and measures complex cross-spectra and sound intensity in addition to all the single-channel functions. Type 2133 is the most advanced sound intensity analyzer in the Brüel & Kjær range.

Large storage capacity and processing ability mean Type 2123/33 can be used as stand-alone instruments in many applications.

Memory

Type 2123/33 has a large internal buffer memory. How many spectra it can hold depends on the frequency range, the fractional octave analysis and the sampling rate. For example, with a frequency range 25 Hz to 20 kHz, the memory can hold 4500 $^1/_1$-octave spectra or 2200 $^1/_3$-octave spectra.

Floppy Disk

The built-in floppy disk unit allows permanent storage of spectra, setups and results, and total or selective recall of measurement data (including Type 2143/44 data). The formatted disk is compatible with PC/MS–DOS, easing the transfer of data to a computer.

Collective Processing

With Type 2123/33 an array of spectra, or multispectrum, can be handled and processed as a single unit, greatly simplifying the analysis of results. The spectra in the multispectrum are indexed using either a one-dimensional system, where spectra are numbered from, say, 1 to 100, or a two-dimensional system, for example by defining a 10×10 array which corresponds to the physical measurement array. Additionally, each element of a multispectrum can be x-, y- or z-labelled. Sets of multispectra can be averaged. A cross-sectional slice or a map of the multispectrum can be displayed, showing the evolution of a frequency band with time or spectrum number.

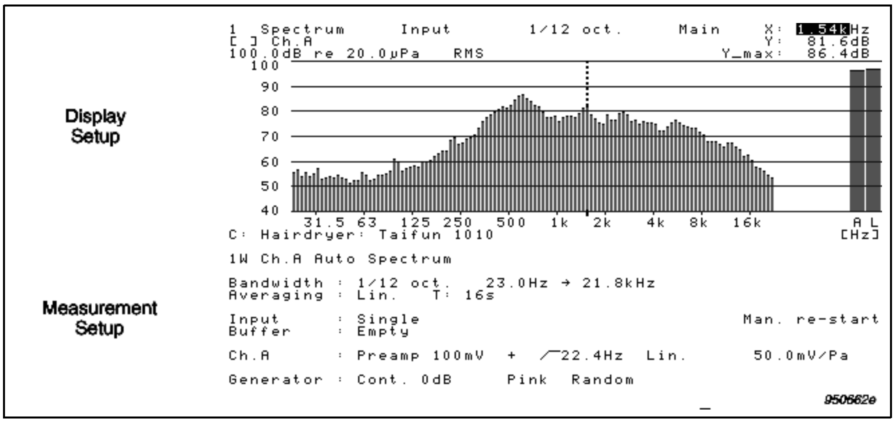

Fig.1 The measurement setup determines the type of measurement made; the display setup determines how the results are presented. Setups can be altered by field entry on the screen

Rapid Data Acquisition

Large numbers of spectra at intervals of as little as 5 ms with no gaps (no loss of data) can be recorded. The measured spectra are automatically loaded into the spectrum storage array, or multispectrum. Subsequent sets of measurements can be averaged into this multispectrum. Major applications are reverberation time analysis, and analysis of sound from rotating or reciprocating machinery, where spectra are measured at equal intervals over the machine's working cycle.

Processing Functions

Most results routinely required in acoustics can be calculated in the analyzer, often in real-time. 57 pre-defined functions in the non-volatile memory cover a range of acoustics applications including sound power determination, reverberation time, sound insulation and absorption, and many routine arithmetical spectrum manipulations. Additional functions can be defined by the user with the help of the powerful and compact mathematical language. Previous programming experience is not required. User-defined functions can be stored in the non-volatile memory and on disk.

Automated Measurements

Many acoustic measurements can be automated using the pushkey autosequence facility. Up to 244 keypushes can be stored in one autosequence. Delays can be put into the sequence to allow for the delays and settling times of any associated equipment in the automated setup. Longer autosequences can be stored on disk in sections and called up in turn by the analyzer.

An IEEE/IEC parallel interface provides convenient access to all raw and processed data in the analyzer, and complete control of all the front panel and soft functions. Standard engineering english interface commands and non-fussy syntax make the interface particularly easy to operate to full advantage.

Ease of Use (Measurement and Display Setups)

Preparing Type 2123/33 is made easy by measurement setups (Fig. 1) which define the measurement mode and the other measurement parameters, such as frequency range, fractional octave, averaging and analogue input. Twelve factory-defined measurement setups covering a range of common applications are stored in the memory. Up to eight user-defined setups, which are retained even when the instrument is switched off, can also be stored. Further setups can be stored on disk.

Similarly, a display setup (Fig. 1) defines the display type (spectrum, slice, time or map), graph axes (range, linear or logarithmic y-axis, reference levels) and the type of data. Eight user-defined display setups can be stored in the non-volatile memory alongside twelve factory-defined display setups, and further setups can be stored on floppy disk.

Display Formats

Data can be displayed in a variety of formats on the 12″ screen. Different display formats are shown in Fig. 2. In addition to the measurement setup format of Fig. 1, there is a full-screen format for a larger display, dual and superimposed formats for easy comparison of spectra, and a table format for listing data. Additional screen text can be typed in for customized documentation.

Measurement Modes 2123/33

The following measurement modes are available in Type 2123/33, for single-channel measurements, with frequency analysis in $^1/_1$-, $^1/_3$-, $^1/_{12}$- and $^1/_{24}$-octaves:

Autospectrum: (spectrum) displayed as: RMS, Power (Pwr), Energy Spectral Density (ESD), or Power Spectral Density (PSD), in dB referred to chosen reference levels, or in absolute units. Also Maximum/Minimum Hold spectra can be measured, with hold on each individual band, or hold of the whole spectrum when a selected band or the A or Linear channel is maximum/minimum.

Time: A time signal can be captured and displayed. The complete signal or windowed parts of it can subsequently be frequency analysed in one or more ways. Signal enhancement, that is, synchronous time-domain averaging, can also be done in the time mode.

Additional Measurement Modes 2133

In addition to the simultaneous measurement of two autospectra (Ch. A and Ch. B), Type 2133 has the following measurement modes with analysis in $^1/_1$-, $^1/_3$- and $^1/_{12}$-octaves:

Intensity: Both active and reactive intensity can be measured using a two-microphone probe or two accelerometers.

Particle Velocity: Particle velocity can be measured using a two-microphone probe.

Mechanical Power: The mechanical power flowing through a point can be measured using a force transducer (Ch. A) and an accelerometer (Ch. B).

Cross-spectrum: Real Part and Imaginary Part can be measured. Also display of Magnitude and Phase.

The mathematical definitions of the different measurement modes of Type 2123/33 are given in Table 1.

Spectrum Weighting

The last two channels in the displayed spectrum are the A-weighted and Linear channels. A, B, C and D spectral weighting can be applied to any measured spectrum. Other weightings can be defined by the us-

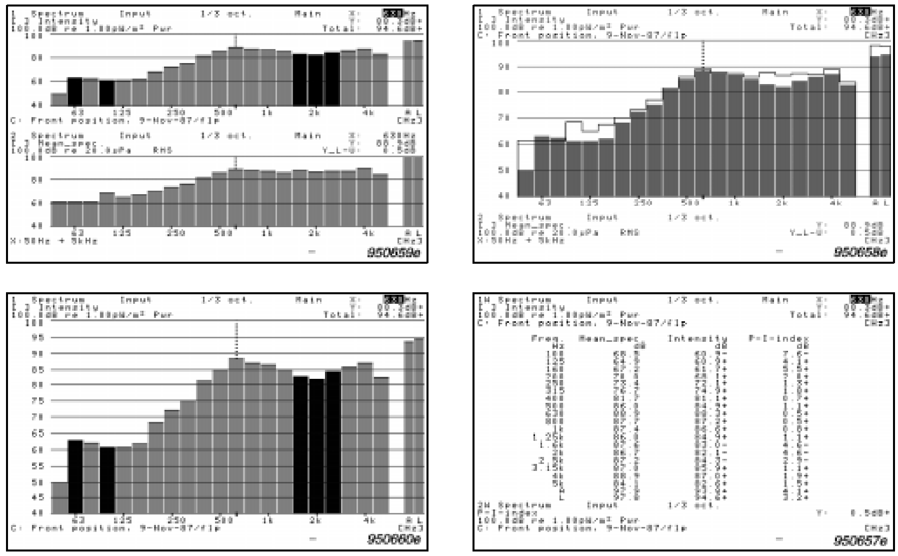

Fig. 2 Different display formats available with the 2123/33. Display of results is determined by the display setup selected from the 12 pre-defined or 8 user-defined setups stored in the non-volatile memory

No.	Measurement Mode	
0	[ ]	
1	Ch. A Autospectrum	$\overline{A^2}$
2	Ch. B Autospectrum	$\overline{B^2}$
3	Mean Spectrum	$\overline{\left(\frac{1}{2}(A+B)\right)^2}$
4	Intensity	$\overline{\frac{A+B}{2\rho\Delta r}\int(A-B)dt}$
5	Reactive Intensity	$\frac{\overline{(A+B)(A-B)}}{2\omega\rho\Delta r}$
6	Particle Velocity	$\overline{\left(\frac{1}{\rho\Delta r}\int(B-A)dt\right)^2}$
7	Cross Spectrum Real	$\overline{AB}$
8	Cross Spectrum Imag	$\overline{A\mathcal{H}B}$
9	Ch. B Vib. Velocity	$\overline{\left(\int Bdt\right)^2}$
10	Mech.Power	$\overline{A\int Bdt}$
11	Ch.A Time	a
12	Ch. B Time	b

A = A(t) = Filter output Ch. A
B = B(t) = Filter output Ch. B
a, b: Time signals Ch. A and Ch. B
H: Hilbert Transform
$\overline{}$: Time average

• Allowed combinations of measurement mode with type 2133. Only half the combinations are shown as the table is symmetrical

	0	1	2	3	4	5	6	7	8	9	10	11	12
0													
1	•												
2	•	•											
3	•	•	•										
4	•	•	•	•									
5	•	•	•	•	•								
6	•	•	•	•	•	•							
7	•	•	•	•	•	•	•						
8	•	•	•	•		•		•					
9	•	•	•	•		•		•	•				
10	•	•	•	•		•		•	•	•			
11	•												
12	•											•	

Table 1 Measurement modes of Type 2123/33, with mathematical definitions. Also shown are the valid measurement combinations in Type 2133

er. For true real-time A-weighted analysis, a digital A-filter can be switched in before the frequency analysis stage.

Real-time Operation

Real-time operation effectively analyses in all the frequency bands simultaneously, without missing any of the input signal. Analysis in real-time is important in measurement of non-stationary signals, such as reverberation time and impulsive signals.

The real-time capability is specified in terms of the highest frequency that the analyzer can process in real time. Fig. 3 shows the analysis frequency ranges and real-time capabilities of Type 2123/33. When measuring in octaves and $^1/_3$-octaves, the analysis is in real-time over the full available frequency range. When analysing in $^1/_{12}$- and $^1/_{24}$-octaves, there is the choice of operating purely in real-time up to a certain specified frequency, or an extended frequency range can be selected, with part of the frequency range not being analyzed in real-time.

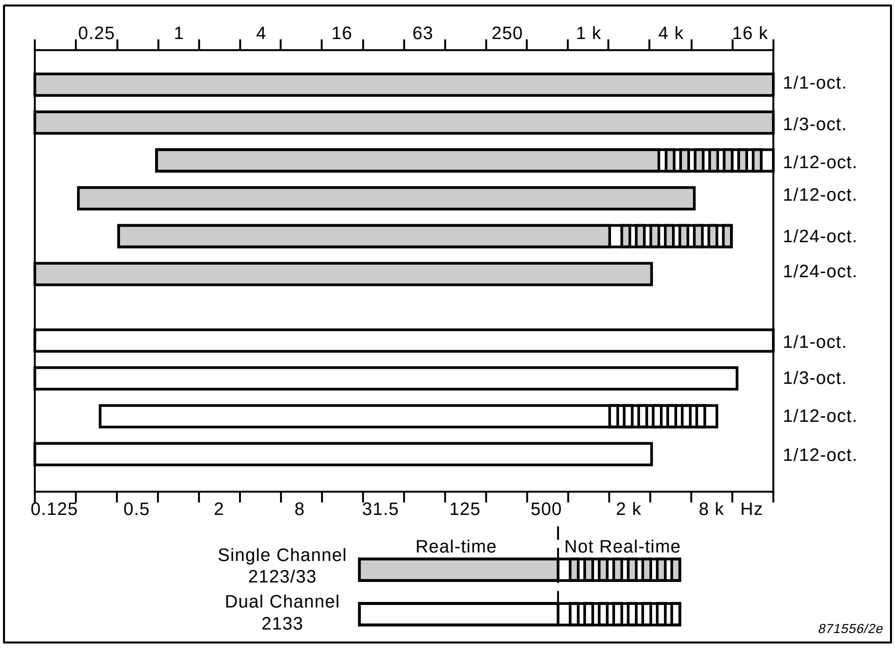

Fig.3 Frequency ranges available in the 2123/33 for the different fractional octaves, and real-time operation range

Data Processing

The 57 pre-defined functions of Type 2123/33 enable the majority of acoustical parameters to be calculated in the analyzer, many of the processing functions being performed in real-time. For example, sound power, sound insulation and absorption, and reverberation time according to various standards, can be calculated. A wide range of spectrum manipulation is also possible, such as arithmetic operations, integration, differentiation and spectrum weighting.

User-definable Functions

Up to eight user-defined processing functions can be stored in the non-volatile memory, and additional functions can be stored on disk. Programming experience is not needed for defining functions, as a high-level language is used. For example, the subtraction of 100 "noise" spectra from 100 "source + noise" spectra stored in the buffer memory, and averaging of the resulting spectra, can be achieved by a statement of the form

Source = AVG(Buffer – Noise)

where "Buffer" represents the measured "source + noise" multispectrum stored in the buffer memory, and "Noise" represents the measured noise multispectrum, stored on disk.

Besides the usual arithmetical operations and mathematical functions, there are some special operators and features which enhance and simplify data analysis. For example:

AVG, TOT: Permit averaging or totalling, on a power basis, of the spectra contained in a multispectrum, over a specified part of the multispectrum.

A, B, C, D: These weighting functions can be applied to (or removed from) a spectrum or multispectrum.

Reverberation Operators: Calculation of reverberation time is implemented in terms of high-level operators which are selected in the processing function field. They operate on the measured reverberation decay curve or on the room impulse function to yield the reverberation time.

Complex Operations: With Type 2133, complex operations can be done. The analyzer handles complex exponential notation.

Bandwidth Conversion: When two spectra of different fractional octaves are involved in a calculation, the analyzer automatically performs the appropriate bandwidth conversion.

Constants: A table of up to 20 constants can be entered by the user, for subsequent use in calculations.

Intensity Measurements

Type 2133 has extensive capabilities for measuring intensity. There are several dedicated intensity measurement setups (Fig. 4) and others can be defined by the user. $^1/_3$-octave sound intensity analysis is real-time up to 11.2 kHz, allowing confident measurements in non-stationary sound fields, and of impulsive sounds.

Besides the usual intensity measurement, namely *active intensity* (propagating energy), Type 2133 also measures the *reactive intensity*, that is the non-propagating sound energy. Particle velocity can be measured on Type 2133 using a two-microphone probe. This can be used, for example, in the investigation of structural intensity (two-accelerometer probe).

Sound Intensity Probes Types 3583 and 3584 can be used with Type 2133. The analyzer/probe combina-

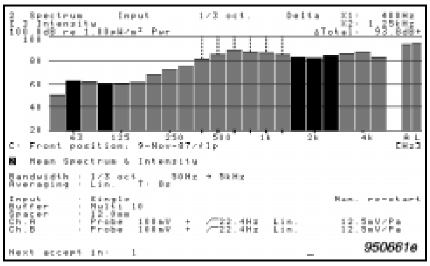

Fig.4 Measurement setup for sound intensity. Input is from the probe input. The direction of sound energy flow is indicated by the brightness of the display and the sign (+ or –) attached to the cursor reading

tion forms a class 1 intensity measurement system according to IEC 1043.

Sound Power

For the measurement of sound power based on the intensity method, Type 2133 has a pre-defined processing function, and the user can define additional functions. Multispectra can be dimensioned to match the physical measurement array, so facilitating data analysis. Field indicators of the measurement accuracy can be calculated using suitably defined processing functions.

Gated Intensity

The multispectrum mode may be used for recording large numbers of intensity spectra, equally spaced over a machine's cycle. Spectrum collection is automatically controlled by trigger signals which mark the machine's cycle. Hence, the emitted sound intensity as a function of the machine's cycle can be rapidly measured.

The averaging gate input enables external control of the averaging process, for analysing selected gated events.

Vector Intensity

In applications such as mapping energy flow in three-dimensional sound fields, the components of the sound intensity in three mutually perpendicular directions, in a defined frame of reference, can be sequentially measured with Type 2133. The complete intensity vector can then be defined. An x, y, z indexing system for the multispectrum provides for this.

Pressure-Intensity Index

The accuracy of a sound intensity measurement depends on the system phase matching and the *Pressure-Intensity Index* of the sound field (pressure level minus intensity level). Type 2133 can simultaneously measure the intensity and pressure levels and display the Pressure-Intensity Index in real-time via a pre-defined processing function (Fig. 5). From a measurement of the phase matching of the sound intensity system, the bias error can be calculated and compensated for using a pre-defined processing function.

Cross-spectrum

Type 2133 can measure the cross-spectrum between two signals. From the real and imaginary parts of the

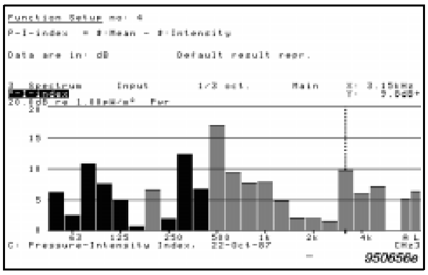

Fig.5 The 2133 displaying the Pressure-Intensity Index in real-time. Other field indicators can also be calculated by means of a suitably defined processing function

cross-spectrum, the phase difference between the two signals is calculated and this is directly displayed on Type 2133 display in degrees (Fig. 6).

The frequency response function of a system can be calculated by dividing the cross-spectrum by an autospectrum, in a two-stage measurement.

Remote Control Unit

The analyzer can be controlled using the Remote Control Unit ZH 0354. For intensity measurements with Type 2133, this can be attached to the Sound Intensity Probe Type 3583. The unit has "Start", "Manual Accept" and "Autorange" pushkeys which duplicate the corresponding ones on the analyzer. The level and frequency of any band can be read on the digital display of the Remote Control Unit. Measurement point numbers (corresponding to a grid) can also be displayed, and changed, in order to repeat measurements at selected grid points. Up to seven pushkey autosequence programs can be activated from the unit. These programs could, for example, store results on a disk, or set the analyzer for a different measurement mode and begin a new measurement. Connection to the analyzer is by a single cable.

Spatial Mapping

Measurement

For spatial mapping, the measurement is made over a rectangular grid surface. The map can then be related directly to the measurement area. Spectra are measured for each grid element and collected together via the Buffer Multispectrum measurement setup of Type 2123/33. Data measured with Type 2143/44 is translated to a buffer multispectrum. The actual dimensions of the grid can be input into the analyzer for both scal-

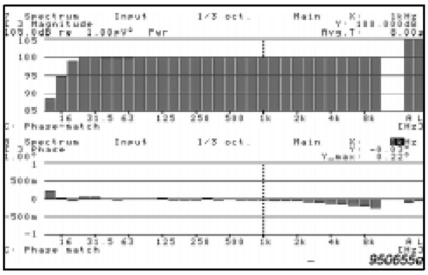

Fig.6 Phase and magnitude of a cross-spectrum displayed on the 2133

ing and use in sound power calculations.

Spatial measurements are often made with 2- or 3-directional measurements at each point. On the mapping displays, you can choose which component of the spatial vector to map. For example, if there are two directional measurements at each point, you can map the components in the x and y directions or the resultant vector in the xy-plane. In addition, a map of the vector's angle to the xy-plane can be selected. For the vector map, at least two measurements must be made at each point.

Landscape Display

The landscape map presents the data in a 3D 'hills and vales' plot (see Fig. 10). For a smoother plot, the measurement values can be interpolated. The interpolation calculates and plots a number of values between the actual measurement points. The landscape can be tilted or rotated, to find the best viewing angle. Measured levels with positive and negative directions can be shown together on the map, or the levels in one direction only can be plotted.

Contour Displays

Two types of contour map are possible: a shaded contour, where the areas between the contours are shaded according to a greytone scale (see Fig. 7); and an outline contour map (see Fig. 8). The contour spacing can be chosen by the user. Up to seven greytones can be used for the shaded contour map.

For both maps, the measured values can be interpolated for a smoother plot. Data levels with positive and negative directions can be shown together, or the levels in one direction only can be plotted.

Number Display

The number map shows the dB levels measured at each position on a plan

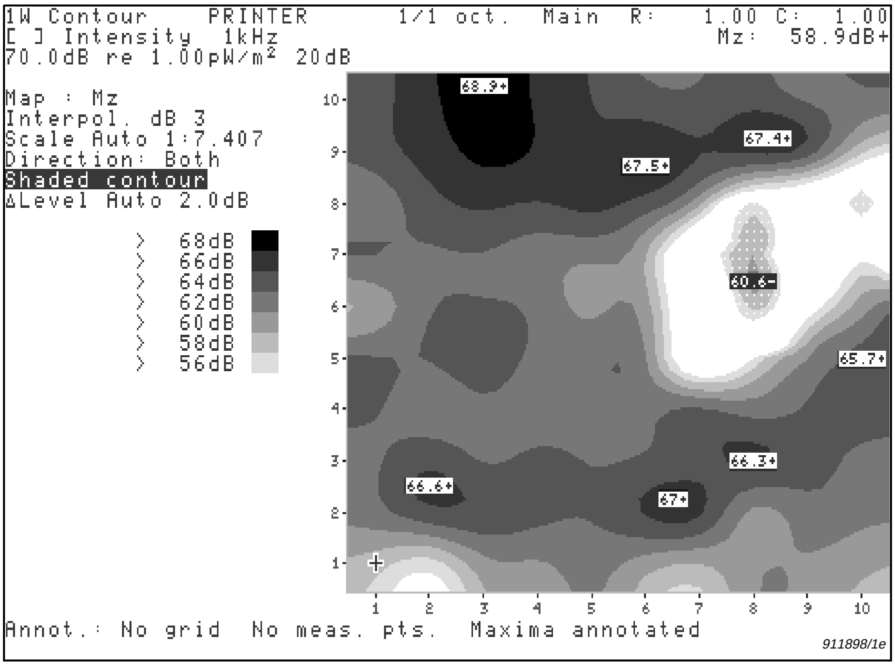

Fig.7 Shaded contour map of intensity field

view of the measurement area. Data levels with negative direction are highlighted. Fig. 9 shows two number maps in the superimposed format.

Vector Display

The vector map has an arrow at each measurement position. The direction and magnitude of the arrow represent the direction and magnitude of the measured vector in the specified plane. Fig. 8 shows a vector map superimposed on an outline contour map.

For vector mapping, at least two spectra must be measured for each grid element in order to define the plane of the map.

Map Annotation

The amount of information on a map can be varied to suit your needs. A measurement grid and the measurement points can be superimposed on the contour, number and vector maps. The measurement points can be specified to lie in the centres or corners of the grid.

On the contour map, all or some of the contours can be annotated, or if they are close together just the maxima can be marked.

Sequential Mapping

Measurement

For sequential mapping, a series of consecutive spectra are collected together via the Input Multispectrum measurement setup of Type 2123/33. Data measured with Type 2143/44 is translated to an input multispectrum. Spectra collection can be at a constant rate, or can be controlled by gating or triggering. Averaged input multispectra can also be mapped.

Display

Sequential data can be displayed as landscape (see Fig. 10), outline or shaded contour (see Fig. 11), or number maps. The parameters in the map display setups are automatically adjusted to suit the sequential data.

Display Formats

The maps can be displayed in all four of the analyzer's display formats. In the dual display format, two different maps can be compared; for example, a landscape map and a contour map. Alternatively, a map can be displayed in one setup while a spectrum or slice is displayed in the other setup. In the superimposed display format, you can combine, for example, a spatial contour and vector map (see Fig. 8) or two number maps (see Fig. 9).

Interpolation

An advanced interpolation technique provides more accurate smoothing than standard interpolation techniques where interpolation curves overshoot at points where the data changes direction. The interpolation used here compensates for overshooting, resulting in a smoother curve that is closer to the ideal. Interpolation of dB values or absolute values is possible.

Cursors

Information can be read from the map displays using the cursor. The three cursor setups of the standard program (i.e., Main, Reference and Delta cursors) extend to the map displays. Additional auxiliary cursor readings cater specifically for the map displays. For spatial maps, the specified cursor coordinates can be either actual measurement positions or interpolation points.

Post-Processing

The post-processing facility of Type 2123/33 can be applied directly to

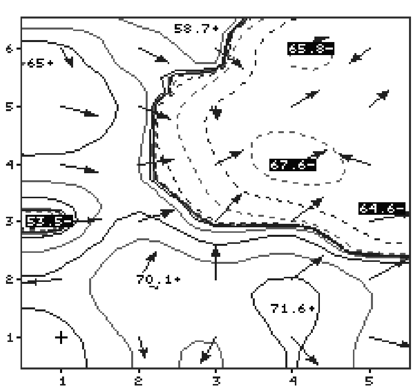

Fig.8 Vector map superimposed on the outline contour

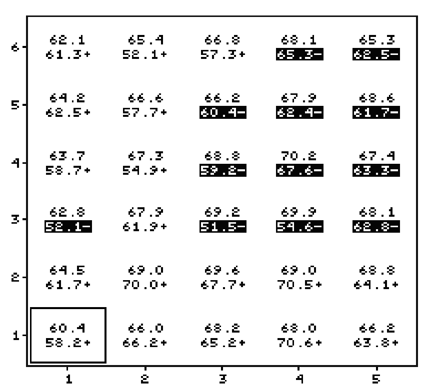

Fig.9 Two number maps superimposed

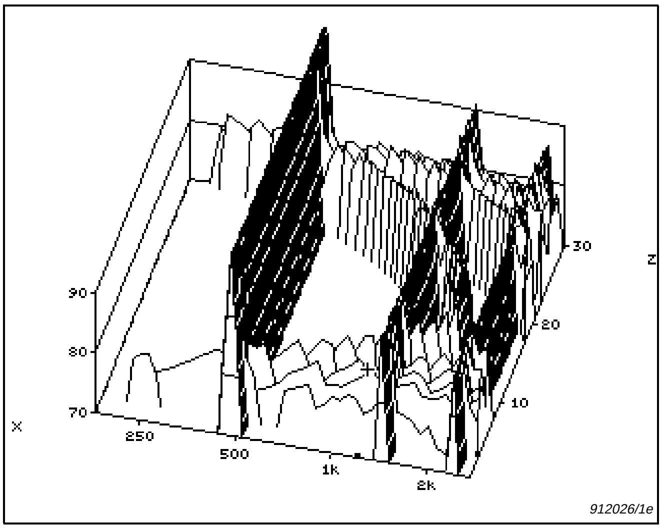

Fig.10 Landscape map of a run-up/coast-down (200 Hz – 2 kHz) measurement. A steady signal at 500 Hz and its harmonics can also be clearly seen

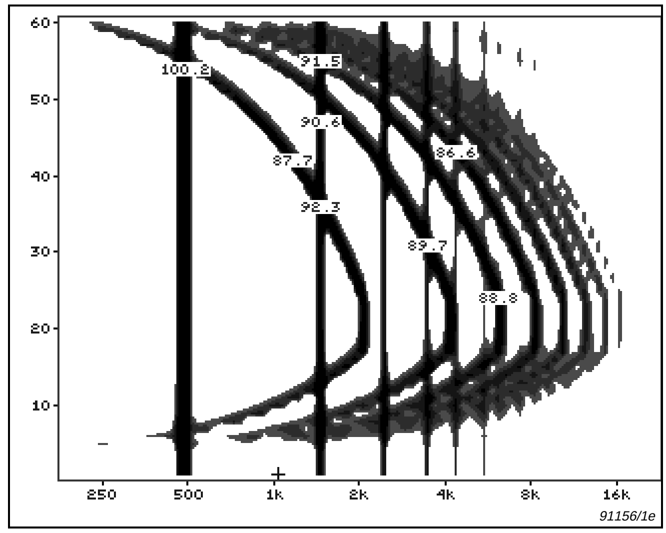

Fig.11 Shaded contour map of run-up/coast-down data (same data as in Fig.10)

multispectrum data in the map display setups. All the setups have a field for selecting post-processing functions. In addition, there are functions for sound power ranking and a special command for re-grouping multispectrum data.

Sound Power Ranking

When analysing a complex machine, source ranking enables comparison of the power content of different segments. Ranking re-positions the spectra in a multispectrum in order of their sound-power content in a specified frequency range. The levels can be compared in a slice display, as in Fig. 12. A ranking list can be displayed in the lower part of the screen.

Re-grouping Multispectra Data

Data from a set of spatial multispectra measured in one plane can be re-grouped to appear as a multispectra measured in another plane. For example, the data from five multispectra of 4 rows (R)×3 columns (C) measured in the *xy*-plane can be re-grouped to create four 5R×3C multispectra in the *xz*-plane, or three 4R×5C multispectra in the *yz*-plane (see Fig. 13).

Spectrum Mode

Triggering Functions

For greater measurement flexibility, the start of input multispectrum averaging can be subjected to certain start conditions specified by the user. The available options are:

Manual: Averaging is initiated manually, with a selectable time delay.

Free Run: Averaging begins as soon as the “Start” pushkey is pressed.

External Trigger: Averaging begins upon an external trigger signal, with selectable time delay.

Generator: Averaging begins upon the generator switching on or off, with selectable time delay.

Conditional: Averaging starts when a specified level is exceeded in a specified frequency band, with a selectable time delay.

Absolute Time: Averaging begins at a specified time. Type 2123/33 has an internal clock.

IEEE: Averaging begins upon a trigger command (Group Execute Trigger) from the IEEE-488 bus.

Detection and Averaging

There is a choice of linear or exponential averaging with selectable averaging times. In addition, there is an equal confidence mode, in which the exponential averaging time of each detector is set to obtain a statistical accuracy (BT product) specified by the user. Where the actual value is less than the specified value, a warning line is generated beneath the spectrum (Fig. 14). The calculated statistical accuracy for a selected band can also be read from the display.

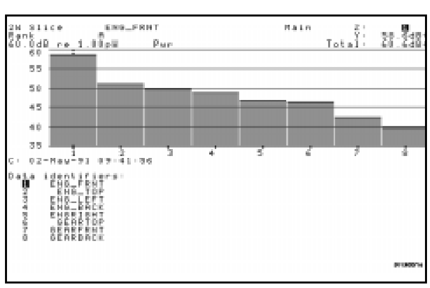

Fig.12 Sound power ranking of different areas of a car engine

Cursor

Information can be read from a spectrum by using a movable cursor. The information and the cursor position are read in the cursor setup. There are three cursor functions:

Main cursor: Shows the level at a chosen frequency.

Delta cursor: Defines a frequency range. The power in this range can be calculated.

Reference: Defines two cursor positions and displays the level difference between them.

There are also many auxiliary cursor readings, see specifications.

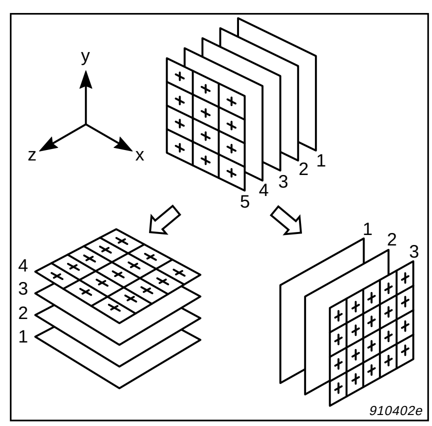

Fig.13 Re-grouping multispectrum data to form multispectra in other planes

Manual Spectrum Entry

Spectral data can be typed into the analyzer to create, for example, a tolerance spectrum, or a special weighting function to be applied to the measured spectrum.

Time Mode

In Time measurement mode, Type 2123/33 records, in digital form, a specified duration of signal with a frequency content up to 22.4 kHz. The captured time signal can be examined on the screen (Fig. 15) and stored on disk for subsequent analysis. Different parts of the record can be analysed by defining an analysis "window". Uniform windowing with cosine tapers can be selected to protect against spectral leakage when analysing short segments of the time function. More than 200 k samples of a time signal can be recorded, which for an upper frequency of 11.24 kHz corresponds to 6.25 s of time signal.

Trigger conditions for a time record can be selected from: free run, signal level, manual, external trigger, internal generator, absolute time or IEEE. A pre-trigger delay of up to one record length and a post-trigger delay of up to 4000 seconds can be selected.

Signal Enhancement

The signal enhancement mode of Type 2123/33 improves the signal-to-noise ratio for the periodic components of a signal by averaging successive time signals. The uncorrelated noise in the input signal is rejected and the periodic components are enhanced. The enhanced time signal can then be analysed. Up to 65 535 time signals can be averaged, each time signal being up to 70 k samples long.

Input/Output

Analogue Inputs Type 3019

Type 2123/33 has high-quality, fully instrumented inputs Type 3019 for connection of microphone preamplifiers and accelerometers, and for direct input of voltage signals from other transducers. All inputs have a dynamic range of more than 80 dB. Analogue and digital overload indications are given on the screen, and autoranging can be selected for all inputs. A range of high-pass filters, and a low-pass filter at 6.4 kHz can be selected for all inputs.

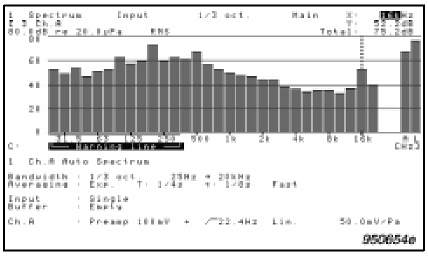

Fig. 14 The error warning line underlines the bands in which the specified statistical accuracy (BT product) is not achieved

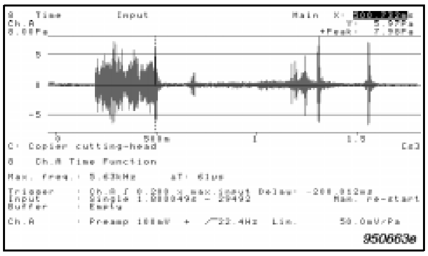

Fig. 15 A time signal captured on the 2123/33. Defined segments can be frequency analyzed

Signal Generator

The signal generator of Type 2123/33 provides pink, white or pseudo-random noise. Noise bursts of selectable duration and spacing can be defined for use in reverberation time measurement. The level of the generator signal is selectable in dB down to – 60 dB referred to its reference level. Measurements can be triggered from the generator, enabling, for example, fully automated measurement of reverberation time.

Interface

Type 2133 has an IEEE/IEC parallel interface over which spectra and time records can be transmitted. All of the functions of Type 2123/33 (apart from polarization voltage, signal ground and display intensity switches) can be controlled over the interface.

Channel Matching (2133)

In dual-channel Type 2133, the responses of the analogue input modules Type 3019 including input amplifiers, attenuators and antialiasing filters, etc., are carefully matched for amplitude and phase response to ensure accurate dual- and cross-channel operation. In Type 2133 the phase matching is typically 0.05° at 20 Hz (0.7 Hz high-pass filter at input). The specified phase matching over the full frequency range is shown in Fig. 16. Amplitude matching between the channels is better than 0.1 dB.

Auxiliary Equipment

Type 2123/33 can control up to four Multiplexers Type 2811, allowing sequential measurements to be automated for up to 32 microphone positions. When spatial averaging of the sound field is required, the Rotating Microphone Boom Type 3923, also controllable from Type 2123/33, can be used.

Hard Copy

Hard copies of the displays are obtained via Brüel & Kjær Graphics Plotter Type 2319 (Fig. 17) or Graphics Recorder Type 2313. Plotters using HPGL, dot matrix printers using PCL (ThinkJet), laser printers (LaserJet) or colour printers (PaintJet) can also be used.

Output formats include a simple screen dump, and plots of spectra in various sizes and orientations (A4 size). Displays can also be output to a video plotter or in TIFF format.

Calibration

Transducer sensitivity, when known, is simply typed into the sensitivity field in the measurement setup. For an overall system calibration, an acoustic reference source such as the Pistonphone Type 4228 or Sound Level Calibrator Type 4230 can be used. Type 2123/33 has a built-in automatic calibration function in which the input sensitivity is automatically adjusted to produce the required calibration level.

A sound intensity system consisting of a sound intensity probe and a Type 2133 analyzer can be rapidly calibrated with the Sound Intensity Calibrator Type 3541. Type 3541 is used to check the intensity level at 250 Hz and to measure the phase matching (pressure-residual intensity index) of the probe/analyzer system. The measured pressure-residual intensity index can then be stored on disk and called upon later for validation of measurements.

Environmental parameters which affect the correct measurement of sound intensity, such as pressure and temperature, are entered into the analyzer's system setup by the user.

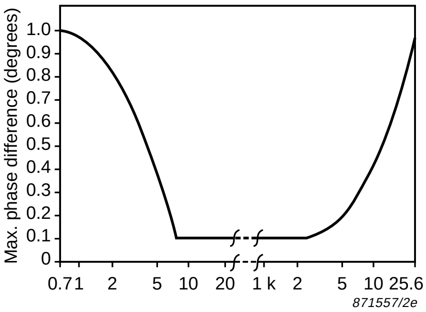

Fig.16 Specified phase matching between the two channels of the 2133, with a high-pass filter of 0.7 Hz and an antialiasing filter of 25.6 kHz

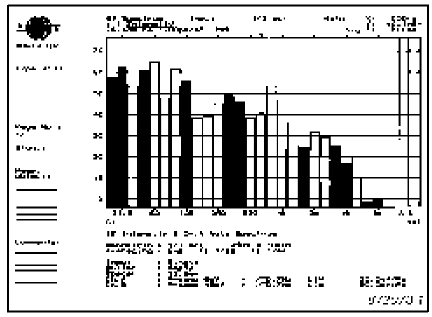

Fig.17 An example of a plot obtained with the Graphics Plotter Type 2319

High-frequency Module ZT 0318

For high-frequency applications, the real-time frequency range of Type 2123/33 can be extended with High-frequency Module ZT 0318 (HF module). In single-channel analysis, the upper limit of the real-time frequency range is increased by a factor of four, allowing a maximum selectable centre frequency of 80 kHz for $^1/_3$-octave measurements (63 kHz for $^1/_1$-octave measurements). Greater real-time frequency ranges in $^1/_{12}$-octaves (up to 21.8 kHz) and $^1/_{24}$-octaves (up to 11.1 kHz), increase the measurement possibilities for analysis of transient signals and fast analysis of stationary signals, e.g., in Quality Control. With Type 2133 and two HF modules, you can measure dual-channel autospectra in $^1/_1$-, $^1/_3$- and $^1/_{12}$-octaves, over the same real-time frequency ranges as in single-channel analysis.

High-frequency Module ZT 0318 also extends the real-time frequency range available in the analysis of data recorded using the time mode facility. Time records can be analysed with a maximum centre frequency of up to 20 kHz, in $^1/_1$-, $^1/_3$-, $^1/_{12}$- and $^1/_{24}$-octaves.

Description

The HF module is an extra circuit board which is installed inside the analyzer by a Brüel & Kjær service engineer in your area.

The filters used in the module are digital filters. They are in accordance with the same standards as the digital filters in the Type 2123/33.

Measurements

The HF module is built into the analyzer as a natural extension. Hence the procedure for high-frequency measurements is the same as for Type 2123/33 alone. No extra training is needed. The measurement setup is specified in the same way with or without the module.

Display

The additional data measured by the HF module, are displayed together with the normal channels on the Type 2123/33 screen.

Processing data

A-weighted and Linear bands may be displayed along with the spectrum (where it is not possible to measure the A and L bands, they can be calculated).

All the post-processing functions of Type 2123/33 (weightings, statistical analysis reverberation calculations etc.) can be applied to the data measured with the HF module. HF data is post-processed together with the data in the normal range. Again no extra training is necessary as there is no change in operation. (Pre-A-weighting is not available with the high frequency range, but the post-processing function for A-weighting can be applied when required). It is possible to disable the use of the HF module via a parameter in the measurement setup. The analyzer then behaves as though the HF module is not installed.

Specifications 2123/2133

Digital Filters:

$^1/_1$-OCTAVE FILTERS:
Single- and dual- (2133 only) channel modes: 14-pole filters. Centre frequencies are $10^{(3n/10)}$, where:
Single-channel mode: $-3 \le n \le 14$. 18 filters with centre frequencies 0.125 Hz to 16 kHz
Dual-channel mode: $-3 \le n \le 13$. 17 filters with centre frequencies 0.125 Hz to 8 kHz
Fulfil IEC 225–1966, DIN 45651 and ANSI S1.11 –1986, Order 7, Type 1-D, Optional Range
Dual-channel mode (2133 only) with upper frequency = 16 kHz: 6-pole filters. Centre frequencies are $10^{(3n/10)}$, where $-3 \le n \le 14$. 18 filters with centre frequencies 0.125 Hz to 16 kHz. Fulfil IEC 225–1966, DIN 45651 and ANSI S1.11–1966, class II
$^1/_3$-OCTAVE FILTERS:
6-pole filters. Centre frequencies are $10^{(n/10)}$, where:
Single-channel mode: $-10 \le n \le 43$. 54 filters with centre frequencies 0.1 Hz to 20 kHz
Dual-channel mode (2133 only): 51 filters with centre frequencies 0.1 Hz to 10 kHz
Fulfil IEC 225–1966, DIN 45652 and ANSI S1.11 –1986, Order 3, Type 1-D, Optional Range
$^1/_{12}$-OCTAVE FILTERS:
6-pole filters. Centre frequencies are $10^{((n+0.5)/40)}$, where:
Single-channel mode: $-30 \le n \le 173$. 180 filters with centre frequencies 0.183 Hz to 5.46 kHz operating in real time, or 180 filters with centre frequencies 0.729 Hz to 21.8 kHz, where the 144 filters with centre frequencies from 0.729 Hz to 2.74 kHz operate in real time
Dual-channel mode (2133 only): $-42 \le n \le 161$. 180 filters with centre frequencies 0.0917 Hz to 2.74 kHz operating in real time, or 180 filters with centre frequencies 0.365 Hz to 10.9 kHz, where the 144 filters with centre frequencies from 0.365 Hz to 1.37 kHz operate in real time
1/24-OCTAVE FILTERS:
6-pole filters. Centre frequencies are $10^{((n+0.5)/80)}$, where:
Single-channel mode: $-84 \le n \le 323$. 360 filters with centre frequencies from 0.0904 Hz to 2.78 kHz operating in real time, or 360 filters with centre frequencies from 0.360 Hz to 11.1 kHz, where the 288 filters with centre frequencies from 0.360 Hz to 1.39 kHz operate in real time
A-FILTER:
Fulfils IEC 651–1979 and ANSI S1.4–1983 Type 0. The A-weighted level is shown in a separate channel. $^1/_1$-, $^1/_3$-, $^1/_{12}$- and $^1/_{24}$-octave spectra can be pre-A-weighted

Detectors:

Digital true RMS detection of Lin. channel, A-weighted channel and filter-set output on 1 or 2 (2133 only) measurements simultaneously. Input 16-bit 2's complement. 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 signal for gating the averaging process
LINEAR:
Averaging without truncation. Averaging times from 1 ms to 36 hours 24 min. 32 s. Resolution: 1 ms from 1 ms to 60 s, max. 3 digits, and 1 s from 60 s to 36 hours 24 min. 32 s. During Lin. averaging the true normalized value is displayed
EXPONENTIAL:
21 averaging times from 1/1024 s to 17 min. 4 s in a binary sequence. 1/4 s and 2 s correspond to Fast and Slow sound level meter responses, respectively
EQUAL CONFIDENCE LEVEL:
Exponential averaging, where the averaging time is varied across the channels to give 68% confidence level < 0.25 dB, 0.5 dB, 1 dB or 2 dB
IMPULSE:
On A-weighted, broadband channel according to IEC 651 – 1979. Only in 1/1-octave single-channel autospectrum or 1/3-octave single- or dual-(2133 only) channel autospectrum

Measurement Modes:

Ch. A Autospectrum
Ch. A Time Function
(see also Additional Specifications 2133)

Measurement Memory:

INPUT MEMORY:
Single Spectrum or Multispectrum
Control: Manual or Auto re-start
Start conditions (multispectrum only): Free run, Manual, External trigger with specified slope and delay, Generator burst start or stop, Absolute time, IEEE or on exceeding a specified level at selectable frequency band after specified delay
Delay: Delay between start condition and actual multispectrum start set in seconds from –1 multispectrum length to 4000 s. Resolution is equal to update rate
Multispectrum update rate: Lin. averaging update rate is the averaging time. Exp. averaging update rate is from 4 ms to 24 hours
Max. no. of spectra: Depends on filter bandwidth, frequency range, measurement mode and update rate. For a 1/3-octave, 25 Hz to 20 kHz, max. no. of autospectra > 2200
BUFFER MEMORY:
Averaged Single Spectrum, Multispectrum, Averaged Multispectrum, Max. Hold Spectrum, Min. Hold Spectrum or Max/Min. Hold Spectrum
Control: Manual or Automatic accept of individual spectra or multispectra. Lin. averaging update on average completion and manual /auto re-start
Number of spectra: Linear average of 1 to 65535 single or multispectra
Multispectra: Individual spectra can be selected and re-measured
Numbering of spectra: Row, column, direction
Hold Functions: On spectrum in input memory for exp. and equal confidence averaging. Runs until stopped
Max. hold: Maximum of averaged values
Min. hold: Minimum of averaged values
Max./Min. hold: Simultaneously Max. and Min. Hold
On all bands: Composite spectrum of max. (and/or min.) RMS values occurring in each channel
On specified band: Retains the spectrum with max. (and/or min.) RMS content in the specified band

Time:

RECORD LENGTH:
More than 200 k samples without averaging and 70 k with averaging. Resolution 1 sample
TRIGGER:
Free run, Internal on channel A or B, External, Generator burst start or stop, Manual, Absolute time or IEEE
TRIGGER SLOPE:
Selectable for external or internal trigger
TRIGGER LEVEL:
Adjustable in 199 steps across the input voltage range for internal trigger
TRIGGER DELAY:
Delay between trigger and start of record set in seconds from –1 record length to 4000 s. Resolution 1 sample

MAX. FREQUENCY:

Max. Frequency	Time Resolution Δt	Max. Record Length, No Averaging. 200 ksamples
22.4 kHz	15 µs	3.125 s
11.2 kHz	31 µs	6.25 s
5.63 kHz	61 µs	12.5 s
2.82 kHz	122 µs	25 s
1.41 kHz	244 µs	50 s
709 Hz	488 µs	100 s
355 Hz	977 µs	200 s
178 Hz	1.953 ms	400 s
89.2 Hz	3.906 ms	800 s

SIGNAL ENHANCEMENT:
Lin. or Exp. averaging of time functions. No. of averages from 1 to 65535
SCAN ANALYSIS:
$^1/_1$-, $^1/_3$-, $^1/_{12}$- or $^1/_{24}$-octave analysis can be performed on a selectable part of a time function or enhanced time function. Window position and width selectable in steps of one sample. Window type: rectangular or rectangular with cosine taper. The time signal can be reversed before analysing

Display:

TYPE:
Built-in 12″ TV-raster scan monitor
PICTURE RESOLUTION:
288 × 488 points
SCALE LINES:
Horizontal scale lines and X-axis check marks are electronically generated directly on the screen to avoid parallax errors
DISPLAY FORMATS:
Full format: A single graph
Dual format: 2 graphs in upper/lower format. The display setups are independently selectable for the upper and lower graphs. The setups can be aligned by pressing **"Align"**
Half format: A single graph with measurement setup
Superimposed: Each graph in full, dual or half format can be a single-trace graph or a dual-trace superimposed graph. Source is independently selectable for each trace
Table format: Any graph can be listed numerically in a table
Menu format: A menu of selectable values for the selected parameter
File list: A directory of the files stored on the floppy disk
System setups: General Setup, Function Setup and 2 pages of Pen plot Setup
ANNOTATION:
Each trace is identified with display setup label, display setup parameters, function name, data source, cursor values, X- (Z-) axis and Y-axis annotation
CUSTOM MEASUREMENT LABEL:
54 characters of user-defined labelling of measurements. The label is stored together with data
TEXT:
32 lines of 61 characters can be used for custom annotation of the display. The text can be stored on disk
Y-AXIS:
Calibration: Data are calibrated using transducer sensitivity and sensitivity adjust from the measurement setup

Annotation: Absolute or relative in dB. Selectable dB reference
Spectra: RMS spectrum, Power spectrum, Power Spectral Density or Energy Spectral Density
Scales: For relative annotation the scale is log. For absolute annotation the scale can be lin. or log.
Log. range: 1 to 999 dB in steps of 1 dB
Y-full scale: Autoscale giving optimum data presentation, or selection of Y-full scale equal to max peak input, or continuous variable using manual setting
Units: Can be units related to the units defined in measurement setup, units defined by the user in display setup, or predefined units
Scaling: Data can be scaled by an absolute factor or a dB value
X-AXIS:
Spectra: Log. with annotation in Hz at 1/1-octave centre frequencies conforming with ISO R266. Range from 1 to 20 octaves. X-low and X-high limit individually selectable
Time: Lin. with annotation in s. Absolute or relative with a selectable reference. Range: 432 continuous samples, a multiple of 432 samples or the complete record. X-start can be specified in steps of 1 sample
Z-AXIS
Slice: In seconds or measurement no. Low and high limit or range individually selectable
ALIGN:
X- (Z-) and Y-axes can be changed to show the data in the best way by pressing **"Align"**
SPATIAL MAP FORMATS:
Landscape map: 3D plot with rotation in horizontal and vertical planes. Minimum rotational increment of 1 degree
Contour maps: Outline or shaded (maximum of 7 greytones)
Vector map: Row–column diagram with arrows representing magnitude and direction of measured vector
Numeric map: Row–column diagram showing measured values
SEQUENTIAL MAP FORMATS:
Landscape map: 3D plot with rotation in horizontal and vertical planes. Minimum rotational increment of 1 degree
Contour maps: Outline or shaded (maximum of 7 greytones)
Numeric map: Time-frequency diagram showing measured values

Cursors:

CURSOR TYPES:
Main cursor, delta cursor, reference cursor
CURSOR SETTING:
Main cursor: X- (Z-) position. Delta cursor and reference cursor: lower limit X1 (Z1), upper limit X2 (Z2) or ΔX- (ΔZ-) value. Cursors on upper and lower graphs can be individually or simultaneously controlled using **"Align"**
CURSOR X-READINGS:
Time X and ΔX: seconds
Frequency X: Hz, ΔX: Octaves
CURSOR Z-READINGS:
Time Z and ΔZ: seconds
Number Z and ΔZ: no.
MAIN CURSOR Y-READINGS:
Calibrated and scaled, absolute or relative. Units as Y-axis
AUXILIARY READINGS:
—Elapsed averaging time
—Averaging time left
—Number of averages performed
—Element number
—Y-max. value
—X-value corresponding to Y-max. value
—Y-min. value
—X-value corresponding to Y-min. value
—Standard deviation
—Sound power
—Total power or total energy
—Power or energy in a delta cursor band
—Delta power/total power
—Reverberation time
—Reverberation time correlation coefficient
—ΔY: difference between Y-values for reference cursor
—Y U-L or Y L-U: difference between Y-values in upper and lower displays
—ΔTot U-L or ΔTot L-U: difference between ΔTot-values in upper and lower displays
—Tolerance check
—Tolerance margin
—Total Sound power
—Δ sound power
—Δ sound power - Total sound power
—Data identifier (label on each spectrum)

Operation:

MEASUREMENT SETUP:
8 complete user-defined measurement setups can be saved and recalled from a non-volatile memory. 12 factory-defined measurement setups are defined in the program. Measurement setup parameters can be changed before or during a measurement
DISPLAY SETUP:
8 complete user-defined display setups can be saved and recalled from a non-volatile memory. 12 factory-defined display setups are defined in the program. Display setup parameters can be changed before, during, or after a measurement
PARAMETER ENTRY:
Via increment/decrement controls, continuously variable speed field entry control, or numeric keypad
INPUT AUTORANGE:
Selects optimum peak input voltage

User-defined Functions:

8 user-defined functions can be saved in non-volatile memory. 52 factory-defined functions are defined in the program. The functions can be calculated and displayed in real-time during a measurement and even changed during the measurement
FUNCTION NAME:
The user can label the function with any name of up to 10 characters
OPERANDS:
Arithmetic operations can be carried out using single real or complex constants or data operands from Input, Buffer or any file
Data operands: Real or complex; single spectrum, multispectrum or slice; single or dual (2133 only) buffer data. 5 pre-defined data operands: A-, B-, C-, D-weighting and Ω
OPERATIONS:
Add, subtract, multiply, divide, raise to power, exponential, log., antilog. or complex conjugate. Specification of reference for dB arithmetic. Total sum, average, slice or single spectrum from a multispectrum. Insertion of a spectrum into a multispectrum. Selection of one set of data from a dual-channel measurement. Combination of two single-channel data sets to one dual-channel data set. Frequency shift of spectra. Deltatotal, deltasum or deltamax from a single spectrum or slice. Absolute value of data. Reverberation or backward integration. Calculation of sound power. Collection of spectra or multispectra into a new multispectrum

Autosequence:

Allows the user to specify an autosequence of front panel keypushes in the "Learn" mode which can be executed on command. Max. 244 keypushes. Program looping: 1 to 65535. Delay: 1 s to 24 hours. Resolution: 1 s. Up to ten independent or interrelated sequences can be saved in non-volatile memory. Stored autosequences can be recalled from disk during execution

System Accuracy:

DYNAMIC RANGE:
All distortion (intermodulation and harmonic) and spurious components at least 80 dB below max. input for max peak input > 10 pC or > 15 mV for $^1/_1$- (6-pole filter order only) and $^1/_3$-octave autospectrum and cross spectrum (2133 only)
NOISE:
Voltage input: Measured in $^1/_3$-octave bands in input range 1 mV with input short-circuited:
0.1 Hz to 40 Hz: < 0.1 µV
50 Hz to 1.25 kHz: < 0.25 µV
1.6 kHz to 5 kHz: < 0.5 µV
6.3 kHz to 20 kHz: < 1 µV
A-weighted: < 2 µV
Lin.-weighted: < 2 µV (10 Hz–22.4 kHz)
Charge input: Measured in $^1/_3$-octave bands in input range 0.3 pC with 1 nF transducer capacitance:
0.1 Hz to 0.63 Hz: < 1 fC
0.8 Hz to 2.5 Hz: < 0.5 fC
3.15 Hz to 160 Hz: < 0.25 fC
200 Hz to 630 Hz: < 0.5 fC
800 Hz to 2.5 kHz: < 1 fC
3.15 kHz to 20 kHz: < 2 fC
A-weighted: < 5 fC
Lin.-weighted: < 5 fC (10 Hz–22.4 kHz)
FREQUENCY ACCURACY AND STABILITY:
0.01% without warm-up (no adjustment necessary)

Signal Generator:

GENERATOR TYPE:
Pseudo-random
SEQUENCE LENGTH:
1, 2, 4, 8, 16, 32, 64 s or 8192 s (random)
WHITE NOISE:
Frequency response: ±0.2 dB, 0.4 Hz to 22.4 kHz. Low-pass filter: 3rd-order elliptic
Output: 1.5 V or 123.5 dBµV, (9.3 mV or 79.4 dBµV)/√Hz
PINK NOISE:
Frequency response: ±0.4 dB, 22.4 Hz to 178 kHz. High-pass filter: 3rd-order Chebyshev
Output: 0.8 V or 118 dBµV, (141 mV or 103 dBµV)/1/3-octave
LEVEL ACCURACY:
103 dBµV ± 0.1 dBµV in 1 kHz 1/3-octave band
OUTPUT ATTENUATOR:
0 to 60 dB in 0.1 dB steps. Accuracy: ±0.2 dB re 0 dB position
OUTPUT:
Floating or single-ended
Output Impedance: 50 Ω
Max. Output Current: 10 mA (typical)
GENERATOR ON/OFF:
Manually or automatically with selectable on and off times from 20 ms to 60 s. Resolution 20 ms

Hard Copy:

Hard copies of displays can be made via the following:
Graphics plotter: Graphics Plotter Type 2319, or any compatible plotter using HPGL. The hard copy has a better resolution than the screen picture. Plots can be in colour
Graphics recorder: Graphics Recorder Type 2313 with any Application Package in 2313.
Matrix printer: As a bit-map dump using ThinkJet
Laser printer: As a bit-map dump using LaserJet
Colour printer: As a bit-map dump using PaintJet
TIFF: Displays can be sent out or stored as a bit-map dump in TIFF format for later use in PC programs such as Word, WordPerfect and PageMaker
VIDEO OUTPUT:
For video hard copy units, recorders and monitors. Composite video signal. 1 V peak-to-peak into 75 Ω

Vertical scan frequency: 50 or 60 Hz
Output impedance: 75 Ω

Mass Storage:

Built-in floppy disk drive for storage of measured data, setups and programs. All or selectable parts of measured data can be recalled
DATA MEDIA:
Removable $3^{1}/_{2}$″ dual-sided, double-density micro-floppy disk
DATA FORMAT:
Compatible with PC/MS-DOS from version 3.2 (except sub-directories)
FORMATTED CAPACITY:
720 kbytes
FILE LIST:
Contains disk identification, user-definable disk name and file list sorting key. Each file is identified by user-definable file name, data type, size and time of storage
DATA COMPATIBILITY WITH OTHER ANALYZERS:
Single spectra and multispectra measured with Type 2143/44 can be read into Type 2123/33 and processed as Type 2123/33 measurement data

IEC/IEEE Interface:

Conforms to IEEE 488.1 and IEC 625-1 standards
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
Controller	C1, C2, C3, C28

DATA:
Any function shown on display, any basic measured data (input or file), postprocessed results, Time History data, Spectrum History data, all setups (measurement, display, cursor, user-defined function, pen plot, general, autosequence), status parameters, custom measurement label, custom display text can be transmitted to and from 2123/2133
REMOTE CONTROL:
All functions and instrument settings excl. floating/signal ground setting and microphone polarization voltage can be remotely controlled
COMMAND SET:
Simple and easy to remember standard engineering english. Resistant to operator error. Syntax errors displayed on screen
CODE:
ASCII (ISO 7-bit) code or Binary
INTERFACE TERMINATOR:
Can be defined from the front panel or from a controller
DEVICE ADDRESS:
Displayable on screen in general setup

Connectors:

REMOTE CONTROL (front panel):
18-pin connector for 2 microphone signals, 15 V power supply and serial RS 422 A interface for Remote Control Unit ZH 0354 or ZB 0017. Otherwise as Preamp. Input for Type 3019
TRIGGER INPUT:
BNT connector for input of external trigger and external measurement start. Supply for Photoelectric Probe MM 0012 and MM 0024: +8 V DC on inner shield of BNT connector
SAMPLING INPUT/OUTPUT:
BNC connector for output of the sampling frequency or, when set to external sampling, input of the external sampling frequency. Maximum sampling frequency: 65536 Hz
AVERAGING GATE:
BNC connector for gating the average
REMOTE CONTROL (rear panel):
8-pin DIN socket for remote control of Multiplexer Type 2811 or Rotating Microphone Boom Type 3923

Power Requirements:

VOLTAGE:
90 – 140 V AC or 180 – 264 V AC
FREQUENCY:
47.5 – 63 Hz
POWER CONSUMPTION
Approx. 350 VA

EMC:

SUSCEPTIBILITY TO DISTURBANCES SPECIFIED IN EN 50082–2:
Measured using Cable AO 1382 (Charge) and Ferrite Cable Clamp LK 0014 or Cable AO 0429 (Voltage) and Ferrite Cable Clamp LK 0013. Floating measurement according to instruction manual

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

Input/Output	Level
Direct[1]	< 7.5 µV
Charge[2]	< 7.5 fC
Preamp., Probe[1]	< 60 µV

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

Input/Output	Level
Direct[1]	< 15 µV
Charge[2]	< 25 fC
Preamp., Probe[1]	< 35 µV

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

General:

CABINET:
Supplied as model A (lightweight metal cabinet) or C (as model A but with flanges for standard 19″ racks)
DIMENSIONS:
(A-cabinet without feet):
Height: 310.4 mm (12.2″)
Width: 430 mm (16.9″)
Depth: 500 mm (19.7″)
Weight: 36 kg (79 lb.)

COMPLIANCE WITH STANDARDS:

CE	CE-mark indicates compliance with: EMC Directive and Low Voltage Directive.
Safety	IEC 348: Safety requirements for electronic measuring apparatus. Safety class II. **Note:** See “Safety” in the Type 3019 specifications.
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: 5 to 40°C (41 to 104°F) Storage Temperature: –25 to +70°C (–13 to +158°F) IEC 68–2–14: Change of Temperature: +5 to +40°C (2 cycles, 1°C/min.)
Humidity	IEC 68–2–3: Damp Heat: 90% RH (non-condensing at 40°C)
Mechanical	Non-operating: IEC 68–2–6: Vibration: 0.3 mm, 20 m/s^2, 10 – 500 Hz IEC 68–2–27: Shock: 650 m/s^2
Enclosure	IEC 529: Protection provided by enclosures: IP 20

Specifications 3019

Input Characteristics:

DIRECT INPUT:
Via BNT socket
Max. peak input voltage: 35 ranges 1 mV to 80 V in a 1, 1.5, 2, 3, 4, 6, 8 sequence
Single-ended or differential
Input impedance: 1 MΩ || 100 pF
Coupling: DC. Input zeroing for automatic DC-offset compensation
High-pass filters: 0.7 Hz or 22.4 Hz
Max. input voltage: 250 V RMS
Max. induced common-mode voltage: 10 V peak for max. input setting 0.3 pC to 8 nC. 1 V peak for max. input setting 10 nC to 80 nC
Supply for Photoelectric Probe MM0012 and MM0024: +8 V DC on inner shield
PREAMP. INPUT:
Via standard Brüel & Kjær 7-pin Preamplifier Input
Max. peak input voltage: 35 ranges 1 mV to 80 V in a 1, 1.5, 2, 3, 4, 6, 8 sequence
Microphone Polarization: 0, 28 or 200 V from 2 MΩ source
Heater Voltage: +6 V (at 200 mA) from 45 Ω source and +12 V (at 200 mA) from 15 Ω source
High-pass filters: 0.7 Hz or 22.4 Hz
ACC. CHARGE INPUT:
Via TNC connector
Max. peak input charge: 39 ranges 0.3 pC to 80 nC in a 1, 1.5, 2, 3, 4, 6, 8 sequence
Single-ended or floating
High-pass filters: 0.09 Hz, 0.7 Hz or 22.4 Hz
Max. induced common-mode voltage: 10 V peak for max. input setting 0.3 pC to 8 nC. 1 V peak for max. input setting 10 nC to 80 nC
SAFETY:
The system complies with safety class II of IEC 348. Safe operation in accordance with IEC 348 is obtained if the voltage of the signal ground, relative to earth, does not exceed 42 V RMS (sine). To ensure safe operation in accordance with IEC 348 at higher voltages, the user must limit all input currents to 0.7 mA peak

COMMON-MODE REJECTION:
0 to 1 kHz:
80 dB for 1 mV to 800 mV input range
60 dB for 1 to 80 V input range
1 kHz to 25.6 kHz:
60 dB for 1 mV to 800 mV input range
50 dB for 1 to 80 V input range
25.6 kHz to 102.4 kHz:
50 dB for 1 mV to 800 mV input range
40 dB for 1 to 80 V input range
Acc. Charge Input:
0 to 102.4 kHz: 40 dB
CROSSTALK:
(Voltage source, 50 Ω; charge source, 1 nF)
Between any two connectors on a module:
–100 dB up to 25.6 kHz
–80 dB up to 102.4 kHz
Between any two input modules:
–120 dB
ATTENUATOR LINEARITY:
±0.1 dB
HIGH-PASS FILTERS:
0.09 Hz, –3 dB. Slope 6 dB/oct.
0.7 Hz, 0.1 dB ripple cut-off frequency. Slope 18 dB/oct. –3 dB frequency: 0.50 Hz
22.4 Hz, 0.1 dB ripple cut-off frequency. Slope 18 dB/oct. –3 dB frequency: 16.1 Hz
PREAMPLIFIER OUTPUT:
Analog output from preamplifier via PCB-connector to optional High-frequency Module Type ZT 0318
Frequency Response: Lower frequency limit (DC, 0.09, 0.7 or 22.4 Hz) to 100 kHz: ±0.2 dB
LOW-PASS FILTER:
6.4 kHz, 0.1 dB ripple cut-off frequency. Slope 18 dB/oct. –3 dB: 8.9 kHz
ANTIALIASING FILTER:
Cut-off frequency: 12.8 kHz or 25.6 kHz
Provide at least 80 dB attenuation of those input frequencies which can cause aliasing. The filter can be bypassed
SAMPLING:
Max. Rate: 65 kHz

A/D CONVERSION:
14 bit
OVERLOAD DETECTION:
On both common-mode and differential signal; applied before all filters
NOISE:
Voltage: At least 80 dB below max. peak input voltage/√($^1/_3$-octave), or 1 µV/√($^1/_3$-octave), whichever is greater up to the 20 kHz $^1/_3$-octave band
Charge: At least 80 dB below max. peak input charge/√($^1/_3$-octave), or 1 fC/√($^1/_3$-octave), whichever is greater up to the 20 kHz $^1/_3$-octave band
DYNAMIC RANGE:
All distortion (intermodulation and harmonic) and spurious at least 80 dB below max. input, for max. peak input > 10 pC or > 10 mV
OVERALL FREQUENCY RESPONSE:
±0.15 dB from lower frequency limit (0.7 or 22.4 Hz) or 0 Hz to upper frequency limit (6.4 kHz, 12.8 kHz or 25.6 kHz)
AMPLITUDE LINEARITY:
±0.1 dB or ±0.015% of max. input, whichever is greater, measured using a sine wave. For measurements more than 40 dB below max. input, the measuring sine wave is accompanied by another sine wave of a lower frequency, having an amplitude not less than 20 dB below max. input
AMPLITUDE MEASUREMENT STABILITY:
Voltage: ±0.1 dB
Charge: ±0.15 dB
(from 0 to –40 dB re max. input level)
CHANNEL TO CHANNEL MATCH:
Max. gain difference: 0.1 dB from lower frequency limit f_L (0, 0.7 or 22.4 Hz) to upper frequency limit f_U (6.4 kHz, 12.8 kHz or 25.6 kHz)
Max. phase difference:
1.1° – 0.1° × f/f_L from f_L to 10 × f_L
0.1° from 10 × f_L or 0 to 0.1 × f_U
f/f_U from 0.1 × f_U to f_U
Modules can be matched to closer tolerances. Contact your local Brüel & Kjær service centre

Additional Specifications 2133

INPUTS:
Two identical channels (Channel A & B). Independent selection of 4 inputs on both channels. Either Direct Input, Preamp. Input, Intensity Probe/Remote Control or Acc. Input

MEASUREMENT MODES:
True dual-channel operation, i.e. both filters and detectors operating in dual channel:
Ch. A Autospectrum
Ch. B Autospectrum
Mean Spectrum
Intensity
Reactive Intensity
Particle Velocity
Cross Spectrum Real Part
Cross Spectrum Imag Part
Ch. B Vib. velocity
Mech. Power
Ch. A Time Function
Ch. B Time Function
User-defined
and several combinations

Specifications ZT 0318

High-frequency Module ZT 0318 expands the real-time frequency range of Types 2123 and 2133. Type 2123 can be expanded with one module and Type 2133 with one or two modules. One module allows single-channel autospectrum measurements in the expanded range. Two modules allow single- or dual-channel autospectrum measurements.

System Performance and Accuracy:

REAL-TIME FREQUENCY RANGE:
Single-channel, ZT 0318 enabled:
$^1/_1$-octave filters: 0.125 Hz to 63 kHz
$^1/_3$-octave filters: 0.1 Hz to 80 kHz
$^1/_{12}$-octave filters: 0.729 Hz to 21.8 kHz
$^1/_{24}$-octave filters: 0.360 Hz to 11.1 kHz
Dual-channel, two ZT 0318s enabled:
$^1/_1$-octave filters: 0.125 Hz to 63 kHz
$^1/_3$-octave filters: 0.1 Hz to 80 kHz
$^1/_{12}$-octave filters: 0.729 Hz to 21.8 kHz
For frequency range measured by ZT 0318 see Digital Filters below
DYNAMIC RANGE:
All distortion (intermodulation and harmonic) and spurious components at least 72 dB below max. input for the frequency range analysed by ZT 0318, for max. peak input ≥ 15 mV or 200 pC
OVERALL FREQUENCY RESPONSE:
± 0.1 dB at filter centres from lower frequency limit (0.7 or 22.4 Hz) or DC to 20 kHz
± 0.2 dB at filter centres from 20 kHz to 80 kHz for voltage input
± 0.5 dB at filter centres from 20 kHz to 80 kHz for accelerometer input with 1 nF transducer capacitance
NOISE:
Voltage input: Measured in 1/3-octave bands in input range 1 mV with input short-circuited: 25 kHz to 80 kHz < 2 μV
Charge input: Measured in 1/3-octave bands in input range 0.3 pC with 1 nF transducer capacitance: 25 kHz to 80 kHz < 4 fC
AMPLITUDE LINEARITY:
In the frequency range analyzed by ZT 0318: ±0.15 dB or ±0.03% of maximum input voltage, whichever is greater, measured using a sine wave input at the filter centre frequency. With measurements more than 40 dB below max. input, the measuring sine wave is accompanied by another sine wave of a lower frequency outside the measured band, having an amplitude > 20 dB below max. input
CHANNEL-TO-CHANNEL MATCH (Type 2133 only):
Max. gain difference: 0.1 dB from lower frequency limit (0.7 or 22.4 Hz) or DC to upper centre frequency limit (80 kHz)

Input Characteristics:

COMMON-MODE REJECTION:
22.4 kHz to 89.2 kHz:
50 dB for 1 to 800 mV input range
40 dB for 1 to 80 V input range
CROSSTALK:
22.4 kHz to 89.2 kHz:
Preamp.- /Acc.- /Intensity-input: –80 dB
Ch.A/Ch.B: –120 dB
ATTENUATOR LINEARITY:
22.4 kHz to 89.2 kHz: ±0.15 dB
ANTIALIASING FILTERS:
Cut-off frequency: 102.4 kHz
Provide at least 84 dB attenuation of those input frequencies which can cause aliasing
INPUT SAMPLING:
Internal: 262.144 kHz
A/D-conversion: 12 bit

Digital Filters:

All filters operate in real time
$^1/_1$-OCTAVE FILTERS:
14-pole filters. Centre frequencies are $10^{(3n/10)}$ where:
Single-channel mode: 2 filters with centre frequencies 31.5 kHz and 63 kHz
Dual-channel mode: 3 filters per channel with centre frequencies 16 kHz to 63 kHz
Fulfil IEC 225–1966, DIN 45651 and ANSI S1.11–1986, Order 7, Type 1-D, Optional Range.
$^1/_3$-OCTAVE FILTERS:
6-pole filters. Centre frequencies are $10^{(n/10)}$, where:
Single-channel mode: 6 filters with centre frequencies 25 kHz to 80 kHz
Dual-channel mode: 9 filters per channel with centre frequencies 12.5 kHz to 80 kHz
Fulfil IEC 225–1966, DIN 45652 and ANSI S1.11–1986, Order 3, Type 1-D, Optional Range.
$^1/_{12}$-OCTAVE FILTERS:
6-pole filters. Centre frequencies are $10^{((n+0.5)/40)}$, where:
Single-channel mode: 36 filters with centre frequencies 2.90 kHz to 21.8 kHz
Dual-channel mode: 48 filters per channel with centre frequencies 1.45 kHz to 21.8 kHz
$^1/_{24}$-OCTAVE FILTERS:
6-pole filters. Centre frequencies are $10^{((n+0.5)/80)}$, where:
Single-channel mode: 72 filters with centre frequencies from 1.43 kHz to 11.1 kHz
Dual-Channel mode: Not applicable

Detectors:

Digital RMS detection of filter-set output on 1 or 2 (2133 only) channels simultaneously. Linear averaging
AVERAGING TIMES:
For single-channel mode, the averaging time is $^1/_{1024}$ s for $^1/_1$-, $^1/_3$- and $^1/_{12}$-octaves and $^1/_{512}$ s for $^1/_{24}$-octaves
For dual-channel mode the averaging time is $^1/_{512}$ s. Further averaging is done in the analyzer

Measurement Modes:

Type 2123/33 with one ZT 0318:
Ch. A Autospectrum
Type 2133 and two ZT 0318:
Ch. A and/or Ch. B Autospectrum

Ordering Information

Type 2123: Real-time Frequency Analyzer, fitted with one input module Type 3019

Includes the following Accessories:

- Mains cable
- AO 0087: BNC to BNC Coaxial Cable
- JP 0802: 8-pin DIN plug
- LK 0013: Ferrite Cable Clamp (for BNC)
- LK 0014: Ferrite Cable Clamp (for Acc.)
- 2 × VF 0057: Spare Fuses F 2A/250V
- 3 × VF 0058: Spare Fuses F 4A/250V

Type 2133: Dual Channel Real-time Frequency Analyzer, fitted with two input modules Type 3019

Includes the following Accessories:

- Mains cable
- 2 × AO 0087: BNC to BNC Coaxial Cable
- JJ 0152: BNC T-connector
- JP 0802: 8-pin DIN plug
- 2 × LK 0013: Ferrite Cable Clamp (for BNC)
- 2 × LK 0014: Ferrite Cable Clamp (for Acc.)
- 2 × VF 0057: Spare Fuses F 2A/250V
- 3 × VF 0058: Spare Fuses F 4A/250V

ZT 0318: High-frequency Module

Includes the following Accessories:

- BZ 5021: Service Program for Type 2123/33
- BZ 5025: Analog Self-test for ZT0318

Optional Accessories

TYPE 2123/33:

Type 4134: Microphone for Type 1 measurements (ANSI)

Type 4192: Microphone for Type 1 and Type M measurements (ANSI)

Type 2669: Microphone Preamplifier

LK 0013: Ferrite Cable Clamp (for BNC)

LK 0014: Ferrite Cable Clamp (for Acc.)

UA 1054: Dual Channel Modification for Type 2123 for upgrading to Dual Channel Real-time Frequency Analyzer Type 2133

UA 1306: Upgrade Kit from disk to PROM-based analyzer including mapping facilities

ZB 0017: Remote Control Handle for remote control of measurements, with LED indication of operations

ZH 0354: Remote Control Unit for remote control of measurements LC display of level, measuring point, etc.

ZT 0318: High-frequency Module. See separate specifications

ZG 0328: Accelerometer Power Supply

WH 2270: Preamplifier Output facilitates output of the conditioned input signals (before the antialiasing filters) to BNC sockets on the rear panel of the analyzer

WB 1118: Lamp Indicator Unit, signals whether a measurement passed or failed preset tolerance limits

KS 0027: Rack Mounting Flanges for conversion of model A to C

QR 1102: 10 $3^1/_2$″ dual-sided, double-density micro-floppy disks

BZ 5021: Service Program for Type 2123/33

Intensity Probe/Remote Control extension cables (capacitance at 1 kHz: max. 10 pF/m)

AO 0324: 5 m

AO 0325: 30 m

WL 0826: Specific length

Interface cables

AO 0264: IEEE–488 to IEC 625–1 (2 m)

AO 0265: IEEE–488 (2 m)

TYPE 2133 ONLY:

Type 3541: Sound Intensity Calibrator for checking the complete intensity measuring system

Type 3583: Sound Intensity Probe including 2 matched microphone pairs Types 4178 and 4181, two $^1/_4$″ microphone preamplifiers, 6, 12 and 50mm spacers, handle and adaptor for mounting probe on ZH0354 Remote Control Unit

Type 3584: Sound Intensity Probe including a matched microphone pair Type 4181 and Remote Control Handle ZB 0017

WA 0447: Mechanics for Assembly of Intensity Vector Probe, using $^1/_4$″ microphones and 12 mm spacer

WA 0491: Mechanics for Assembly of Intensity Vector Probe, using $^1/_2$″ microphones and 50 or 150 mm spacers

WT 9378: Mapping and Sound Power Program for IBM AT and PS/2. Contour, 3D and Vector maps of spatial multispectra (row and column axis), sound power determination and sound power ranking

Type 7679: Sound Power Program for PC. Allows determination of sound power according to ISO 9614–2 (survey or engineering grade), ECMA 160 (engineering grade) and ANSI S12–12

Brüel & Kjær

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