Application Notes

Measurement of Sound Reduction Index with the Single/Dual Channel Real-time Analyzers Types 2123 and 2133

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1. Introduction

Determination of sound insulation according to the International Standard IS0 140 or equivalent standards can be accomplished directly by using the Single/Dual Channel Real-time Analyzer Type 2123 or 2133.

This application note describes features important to measurement of the sound reduction index, and includes information about user-defined functions, data storage and presentation of results.

2. Standards

The principle of a standardised measurement of sound reduction index is that noise is emitted into the room on one side of the test specimen, whereafter the sound pressure level is measured at both sides of the test object. Based on the level difference and some corrections — see below — the sound reduction index is calculated.

This principle is used for laboratory measurements of the sound reduction index of a building element and for field measurements of the corresponding field quantity, the apparent sound reduction index. The measurement procedures may be identical, but the results are denoted slightly differently, $\boldsymbol{R}$ and $\boldsymbol{R'}$, respectively.

According to the international standard IS0 140/3 [l], the sound reduction index is found from:

$$\boldsymbol{R} = L_1 - L_2 + 10 \log \frac{S}{\boldsymbol{A}} \qquad (1)$$

where

L_1 = average sound pressure level in the source room
L_2 = average sound pressure level in the receiving room
S = area of the test specimen
$\boldsymbol{A}$ = equivalent absorption area in the receiving room

The equivalent absorption area $\boldsymbol{A}$ is evaluated from:

$$A = \frac{0{,}163\, V}{T}\ [\mathrm{m}^2] \qquad (2)$$

where

$\boldsymbol{V}$ = receiving room volume [m^3]
$\boldsymbol{T}$ = reverberation time in the receiving room [s]

The equation for the determination of the sound reduction index is found by combining eqs. (1) and (2):

$$\boldsymbol{R} = L_1 - L_2 + 10 \log \boldsymbol{T} + 10 \log \frac{S}{0{,}163\, \boldsymbol{V}} \qquad (3)$$

Consequently, the determination of the sound reduction index requires:
- Measurement of sound pressure level L_1 in the source room
- Measurement of sound pressure level L_2 in the receiving room
- Measurement of reverberation time $\boldsymbol{T}$ in the receiving room
- Knowledge of the area S of the test specimen
- Knowledge of the receiving room volume $\boldsymbol{V}$

According to [l], the sound reduction index should be determined per 1/3 octave in the frequency range 100 – 3150 Hz.

The sound pressure levels and the reverberation time are spatially averaged values. The standard does not require a certain number of microphone positions or a certain length of a microphone path, but the precision of the measurement results should fulfil the requirements laid down in IS0 140/2 [l]. The spatial averaging is carried out by using a rotating microphone boom, a microphone array or a single microphone moved from position to position. Examples of test procedures are found in IS0 140.

Most national standards about measurement of the sound reduction index describe methods equal or similar to the IS0 method. Some details may be different, but this does not normally influence the principles of the measurement. As an example, the American standard ASTM 90-85 [2] prescribes the frequency range 125-4000Hz, which is shifted by 1/3 octave compared to IS0 140 [l], and the denotation of the final result is different. However, apart from this, the measurement procedure may be the same. Consequently, a measurement carried out according to the ISO-method may serve as a useful example in general.

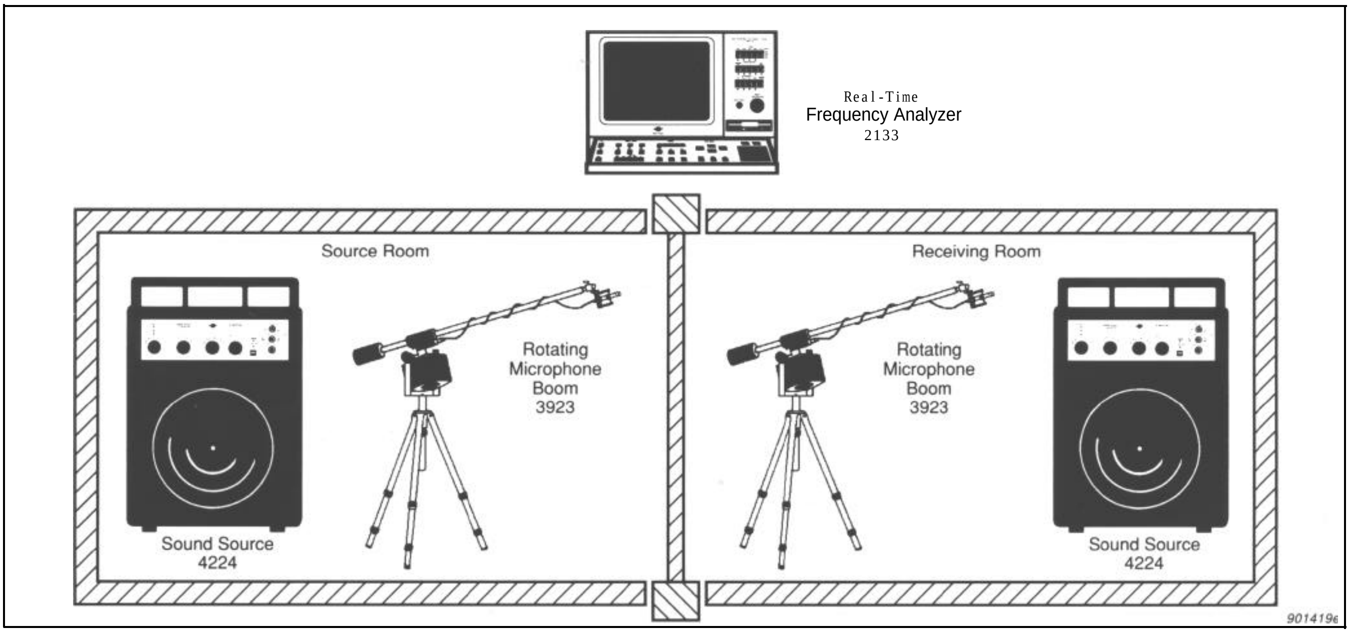

Fig. 1. Typical instrumentation for laboratory measurement of airborne sound insulation

3. Measurement of Sound Reduction Index using 2123 or 2133

The sound reduction index can be measured using the single-channel analyzer 2123 as well as the dual-channel analyzer 2133. However, the measurement is basically a two-channel measurement, and in principle the measurement of sound pressure level should be carried in both source and receiving room simultaneously. Only if the noise signal is stable, is a single-channel analyzer sufficient. Measuring, for example, the sound insulation of facades using traffic noise as the sound source requires a dual-channel analyzer according to IS0 140/5 [l]. Apart from the number of channels and the related performance, the 2123 and 2133 are identical.

Typical laboratory instrumentation is shown in Fig. 1.

Some of the features important to measurement of the sound reduction index are described below. For full information about the possibilities, see instruction manual.

3.1. Remote control of a rotating microphone boom or a multiplexer
Spatial averaging of the sound pressure level as well as the reverberation time is required according to IS0 140. This may be done by moving a single microphone from position to positiion but the average sound pressure level is more conveniently measured by using a Rotating Microphone Boom Type 3923 or a Multiplexer Type 2811 controlled via the remote control socket on the rear of the analyzer. The remote control signal is activated via a special parameter in the analyzer's general setup.

3.2. Noise generator
A noise signal is emitted in the source room, when measuring level difference, and in the receiving room, when measuring reverberation time. The analyzers have a built-in noise generator with output on the front panel of the analyzer. The generator can be switched on continuously for the level measurements, or with a selectable on and off-time for the reverberation time measurements, see Fig.2 and 3 (bottom lines of measurement setups).

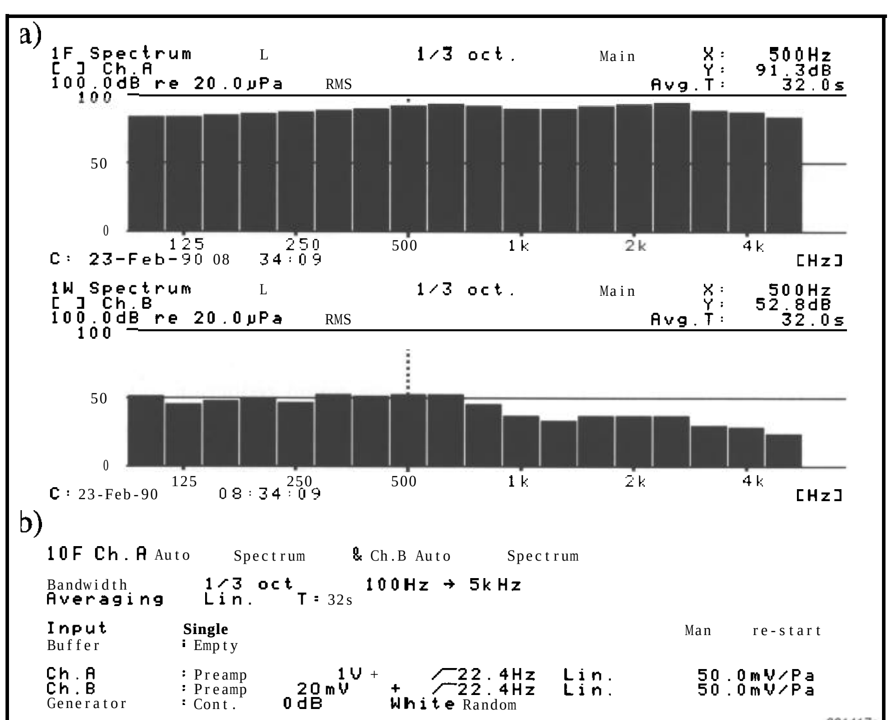

Fig. 2. Examples of display and measurement setups for measurement of source and receiving room levels with the Dual Channel Analyzer 2133, averaging time 32s. Rotating Microphone Booms Type 3923 are used for the measurement
a) Source room level (upper display) and receiving room level (lower display)
b) Measurement setup

3.3. User-defined functions

The raw data consist of the measured spectra in the source and receiving rooms and the spectra measured in the receiving room during the decays. The sound reduction index is calculated from these data using user-defined functions, abbreviated UDF. A basic introduction to UDFs is found in [3].

The reverberation time is evaluated using the built-in function "Reverb" (No.50). Default values for the starting point and range of the evaluation are 5dB below steady state level and 20dB range, but these values are user-selectable, see e.g. [4], so they can be chosen according to the guidelines found in the standard in question.

The sound reduction index according to (3) is calculated using a corresponding user-defined function, e.g. the built-in function (No. 57).

Any part of the built-in functions as well as the names can be changed at will. In general UDFs should be specified conveniently, considering the specific measurement procedure in question. For example correction for background noise can be included in the function. If the procedure used includes more complete measurements of sound insulation, e.g. using different loudspeaker positions, the final result can easily be found specifying a UDF which calculates the average.

3.4. Measurement setup and display setup

The details of a measurement, e.g. frequency range, averaging time, number of spectra, etc., are specified in measurement setups, which can be tailor-made to correspond to the measurements required.

The data – directly measured or postprocessed – are shown on screen using an appropriate display setup. The source of the basic data to be used is specified. If postprocessing of these data is wanted, a function is selected.

An example of measurement and display setups for measurement of source and receiving room levels with 2133 are shown at Fig.2. The data shown in the display of Fig. 2 are the source and receiving room levels measured using the Rotating Microphone Boom Type 3923.

For measurement of reverberation time, the setups are changed, see e.g. example of measurement setup in Fig. 3.

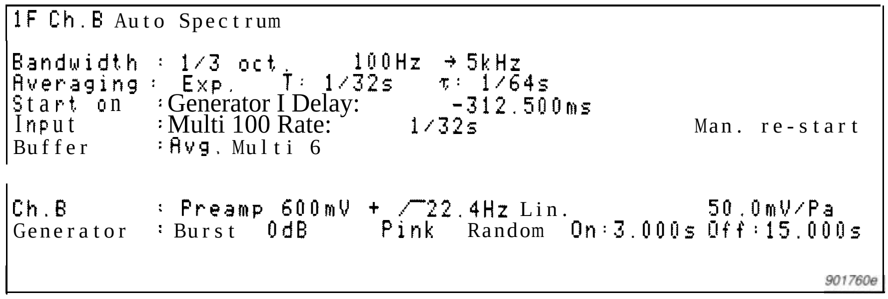

Fig. 3. Example of measurement setup for measurement of reverberation time. This setup can be used for a measurement carried out at 3 positions on the microphone path (3923) with 2 excitations in each position.

3.5. Storage on disc

All types of measured and postprocessed data can be stored on disc. Storage is activated by using "Store" and by specifying what should be stored and the name of the file.

Furthermore, the disc is useful for storage of measurement setups, user-defined functions, constant tables, user texts, screen dumps, etc.

The analyzer's disc drive is designed for 3 1/2" micro floppy discs and the format is compatible with PC/MS-DOS 3.2. The capacity of one disc is 720kbytes or 112 files. Before use, the disc is formatted in the analyzer by one of the built-in disc commands. Back-up data discs are created using another command, which copies all files on one disc to another disc by inserting source and destination discs in turn.

The data stored on disc can be used for several purposes. First of all the data file is a simple means of keeping the data. Second, the data can later be recalled for further processing or for comparison with other data. Furthermore, the data and the information stored with the data are important for documentation and hard-copy, see below.

3.6. Documentation

A data file on disc consists of results and some additional information documenting the results. When storing e.g. the measured source and receiving room level, the measurement setup, comments line and the display setup are stored along with the data. The comments line contains date and time when start/trigger conditions are fulfilled, and comments written by the user. If postprocessed results are stored on disc the UDF used is stored with the data.

The measurement setup and comments line stored with the data are very important as documentation, e.g. in cases where traceability of measurement results is a requirement.

3.7. Hard copy

Hard copy documentation for reports is made by using either a printer or a plotter connected to the analyzer via the interface.

Screen dump

Specifying a matrix printer as the receiving device, the plot pushkey activates a screen dump which is very similar to what is seen on the screen. Examples of screen dumps are found in Fig. 2 and 3.

Pen plot

Specifying a plotter as receiver, the standard type of plot is a screen "copy". However, the flexibility is quite extensive, since e.g. size, scaling of axes, graph type and line type can be varied. Furthermore, more types of plot are available, and pen numbers, i.e. colours and/or thicknesses, can be chosen at will for different parts of a total plot. New graphs with new graph types and/or line types and/or colours may be added after completion of an earlier plot, meaning that several graphs may be drawn on the same plot.

The pen plot information defining a plot can be used immediately by pressing the plot pushkey. Alternatively, the plot information can be stored in a disc file containing the HPGL commands, which can be recalled later by the analyzer or a computer.

A plot example is found in Fig. 4.

Table

Any displayed table of results can be printed or plotted by specifying a matrix printer or plotter as the receiver. However, a hard copy of a table on a printer is very conveniently made by selecting table as the digital output. In this case the table is printed in ASCII-characters, and the frequency range can be chosen independently of what is shown on the screen.

4. Rating of results

Measurement of the sound reduction index *R* according to IS0 140 [l] gives frequency dependent values. Another standard, IS0 717 [5], describes a method used for conversion of these values into a single number quantity characterizing the acoustical performance of the test specimen. This quantity is called the weighted sound reduction index and denoted *R*,. The principle of the method is that the measured R-curve is compared to a reference curve, which is shifted in steps of 1 dB until the mean unfavourable deviation of the R-values is as large as possible, but not more than 2,0 dB.

Determination of R_w may be carried out by utilizing UDF No 10, which calculates the mean unfavourable deviation corresponding to the R_w-value proposed in the constant table, see instruction manual for details. The correct R_w is found by manually changing the value stepwise until the condition is fulfilled, i.e. the displayed result of the UDF is as large as possible, but not more than 2,OdB. This stepping cannot be carried out completely automatically, because the stepping is conditional, and UDFs are designed for straightforward calculations.

After having determined the R_w-value, the corresponding reference curve may be displayed – using UDF No 11 – and compared to the measured *R*-curve. This is illustrated in Fig.4.

Rating of results according to other standards may be carried out using similar UDFs created on the basis of the built-in functions and saved in the memory of the analyzer or stored on the disc.

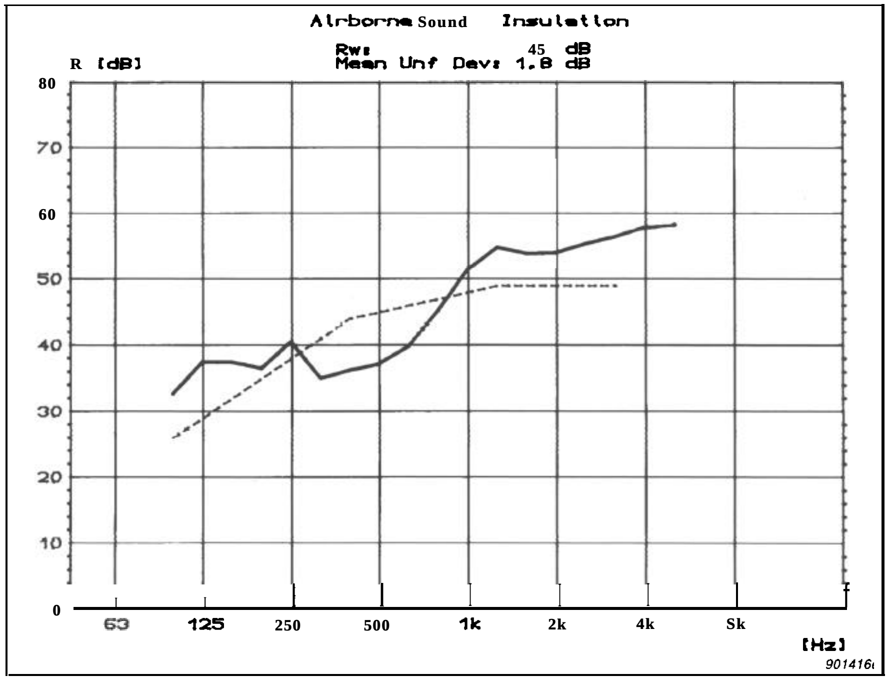

Fig. 4. Measured sound reduction index as a function of frequency (solid line) and the corresponding reference curve (dashed line). The figure is produced using Graphics Plotter Type 2319 connected to the analyzer. The text above the diagram is user-specified

5. Automated Measurement

Measurements of sound reduction index are greatly simplified and made much faster by making use of autosequences, which are programmed sequences of key-pushes. The writing of autosequences is simplest if pre-stored setups and functions are used. The autosequences are conveniently stored in an "all setups-file" together with relevant measurement and display setups and UDFs.

Any keystroke may be built into an autosequence, e.g. switching the generator on or off, starting a measurement, autoranging, storing data on disc, postprocessing data, printing results. Furthermore, recall of texts can be automated meaning that explanations and prompts can be shown on the screen whenever useful to the operator.

As an alternative or supplement to autosequences, the analyzer can be controlled completely from a computer via the IEEE-interface, which can also be used for data transfer.

Conclusion

As described, sound reduction index can be directly measured using the Real-time Frequency Analyzers Types 2123 and 2133. Examples of measurement setups, user-defined functions, etc. are given. Selected parts of the procedure are described and illustrated with printouts and plots produced by connecting the analyzer to a printer or plotter, respectively.

References

[1] IS0 140 *"Acoustics-Measurement of sound insulation in buildings and building elements"*
Part 2: *"Statement of precision requirements"*
Part 3: *"Laboratory measurements of airborne sound insulation of building elements"*
Part 4: *"Field measurements of airborne sound insulation between rooms"*
Part 5: *"Field measurements of airborne sound insulation of facade elements and* facades"

[2] ASTM E90-85 *"Laboratory measurement of airborne sound transmission loss of building partitions"*

[3] *"User-definable Functions in the Real-time Frequency Analyzers Types 2123 and 2133"*, B & K Application Note, BO 0323

[4] "Measurement *of Reverberation Time with the Single/Dual Channel Real-time Analyzer 2123/33"*, B & K Application Note, BO 0190

[5] IS0 717: *"Acoustics – Rating of sound insulation in buildings and of building elements"*

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