

Calculation of Single Values in ArtemiS

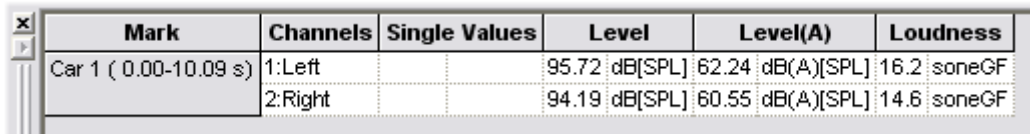
Determining a single, or overall, numerical value is useful in a variety of applications. For example, signals under investigation can be ranked by means of these values.

ArtemiS gives two options for calculating single values: 1) the **dB** button on the ArtemiS control toolbar, and 2) the "Single Value" selection available in diagram legends.

The two possibilities will usually be based on different calculation instructions; therefore the results may differ. The causes of such differences will be described.

dB Button

Single values of the following analyses can be obtained by pushing the **dB** button in the ArtemiS toolbar: Level, A-weighted level, B-weighted level, C-weighted level, D-weighted level, loudness and sharpness. After a data file in the source pool of an Artemis project is selected, this button can be clicked and the result will appear in the output window at the lower screen margin (figure 1).



Mark	Channels	Single Values	Level	Level(A)	Loudness
Car 1 (0.00-10.09 s)	1:Left		95.72 dB[SPL]	62.24 dB(A)[SPL]	16.2 soneGF
	2:Right		94.19 dB[SPL]	60.55 dB(A)[SPL]	14.6 soneGF

Figure 1: Single values of a sample signal calculated in clicking the dB values button

Which analysis with which settings will be calculated can be specified under „options -> settings -> show dB levels“ (see figure 2).

Under "Parameters" the analyses are selected. Depending on the selected analysis, different configuration possibilities will be (de-)activated. Once a level calculation (level L, A-weighted level L(A), B-weighted level L(B), C-weighted level L(C), D-weighted level (L(D)) has been selected, the user can also determine whether the DC magnitude needs to be considered („Calculation of level with DC“) and whether the single value shall be displayed in dB or directly in the original units of measurement („Calculation of level in dB“). Settings such as „Loudness method“, „window function“, etc. can be selected for analyzing loudness (N) and sharpness, depending on the method. These settings and their effects on calculation comply with the settings for loudness and sharpness calculation available in the Analysis Pool. They can be found in greater detail in the Application Note "Psychoacoustic Analyses I".

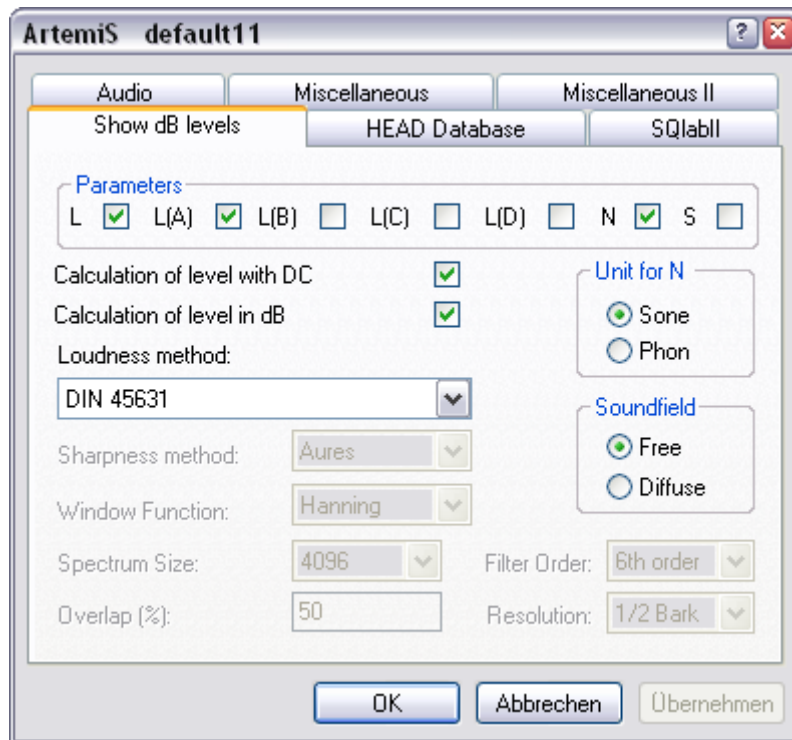


Figure 2: Properties Dialog of the dB Button

Calculation Algorithms

Level

For level, the individual values at each clock step along the time history of the time signal are squared, added, and then divided by the number of clock steps to obtain the single values. If “Calculation of level in dB” is active, the value will be converted into the dB unit and displayed. Otherwise the rms-value is displayed.

Loudness

The calculation of loudness (N) first requires a 1/3-octave spectrum that is obtained through averaging over the total length of the time signal. Partial loudnesses are calculated from this spectrum according to the calculation method selected in the corresponding selection box. Through their integration the total loudness is obtained. When using “FFT / ISO 532 B” the calculation of the averaged 1/3-octave spectrum is based upon FFT spectra calculated with the window size specified in the selection box “spectrum size”, while in the setting “Filter / ISO 532 B” the 1/3-octave levels are determined through filtering (selectively using 4th or 6th order filters). Both methods correspond to the specifications of the ISO standard. The calculation method “DIN 45631” is identical to the method “Filter / ISO 532 B” using 6th order filters. The calculation method is described in the German standard DIN 45631. The methods “FFT / ANSI S3.4-2007” and “FFT(3rd Oct) / ANSI S3.4-2007” comply with the loudness calculation methods described in the standard ANSI S3.4-2007. For these methods the window size for the FFT spectrum is specified in the selection box “Spectrum Size.”

If the method “FFT / HEAD” in the menu box “Loudness method” is chosen, partial loudnesses are not calculated according to a standard, but according to the loudness algorithm developed by HEAD acoustics.

The differences among the various calculation methods are explained in detail in the Application Note "Psychoacoustic Analyses I".

Sharpness

The calculation of sharpness (S) is based on partial loudnesses which, as described above, are determined from an averaged 1/3-octave spectrum. For the sharpness calculation too, several algorithms are available in the "sharpness method" box. The sharpness will be calculated according to the selected sharpness method, and also according to the loudness method concurrently selected.

The setting options regarding sharpness are described in the Application Note "Psychoacoustic Analyses I".

Single Value Function in the Diagram

This function is available after an analysis has been calculated in ArtemiS and the result is displayed in a Data Viewer or Mark Analyzer. The single values display is obtained in the diagram legend. By right-clicking on the graph legend the function "Single Value" can be activated, and a single value of the displayed analyses will appear. Furthermore, the single values can be displayed in the ArtemiS output window and/or exported to a log file via the function "Single Value Export" available in the Destination Pool. The result for the single value depends on the settings selected on the Properties Dialog of the analysis. In addition, the algorithm for single value calculation is not the same for all analyses. The following examples show some different approaches.

Calculation Algorithms

Level analysis

For the analysis level vs. time, which displays the level of a signal as a function of time, the single value displays an averaged level. Figure 3 shows such an analysis.

The single value calculation shown in the diagram is made by averaging the squared sound pressures. But the time signal is initially run through an integration filter for a time weighting. The time weighting setting can be specified in the Properties Dialog of the level analysis. The time signal is exponentially averaged with a time constant according to this setting. In the setting "fast" the time constant is 125 ms, while with the setting "slow" it is 1 sec. The values resulting from the analysis are averaged to calculate the single value.

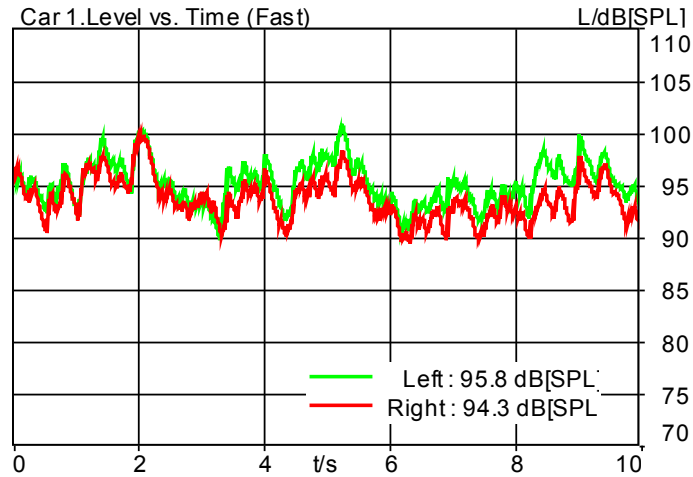


Figure 3: Level single value of a level vs. time analysis (time evaluation “fast”)

In the level analysis displayed in figure 3 the setting “fast” was selected. Figure 4, by comparison, represents a level analysis of the same signal, where the time evaluation was set to “slow”. The single value per channel differs slightly from the one given in diagram 3. The variance can lead to a difference in the single value, especially if the time constant is significantly different relative to the signal length.

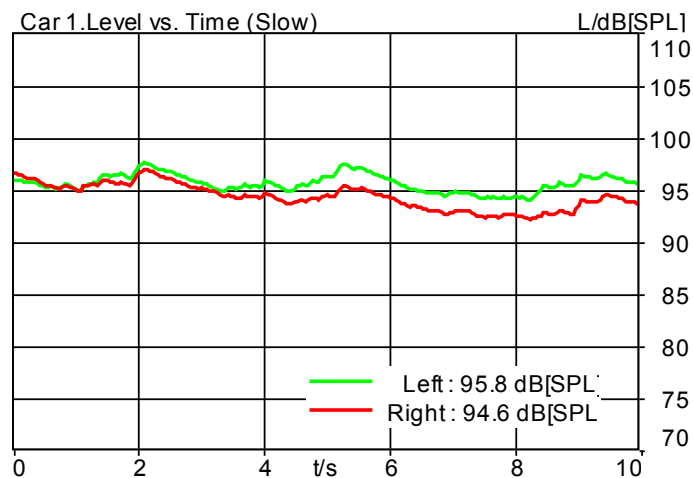


Figure 4: Level single value of a level vs. time analysis (time evaluation “slow”)

FFT Analysis

Similarly, in the FFT analysis (average), the single value function calculates a level value. In this analysis the level is displayed versus frequency in the diagram. For this purpose the data have already been averaged over time. In other words it is no longer necessary to average over time, but to sum over all frequencies in order to calculate the single value.

The sound pressure values of each individual frequency are squared and integrated versus frequency. The single value depends on the analysis setting selected from the Properties Dialog of the analysis, e.g. the window size and window function. Figure 5 shows an example of an FFT analysis with the corresponding single value.

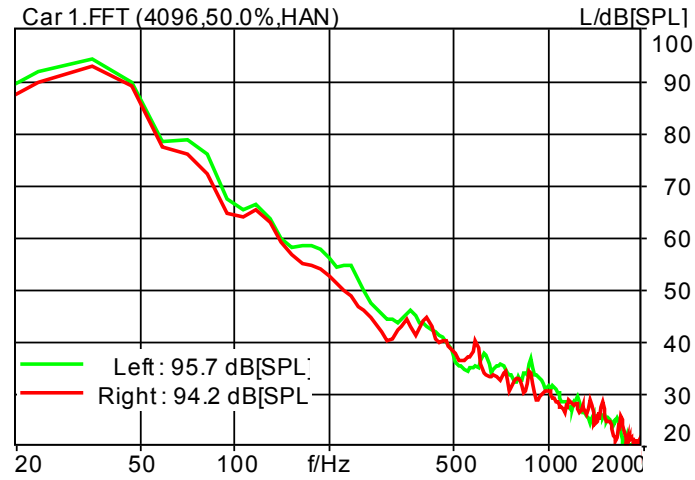


Figure 5: Level single value of an FFT analysis (average)

Loudness Analysis

If a loudness analysis is performed, a single value of loudness is determined through the single value function. Figure 6 displays a diagram with the single value from a specific loudness analysis.

For this analysis the time factor has already been averaged and the specific partial loudnesses have been obtained as a function of frequency. The single value is determined by integrating versus frequency. The procedure to calculate the single value for this analysis corresponds to the method selected in the settings for the dB values button. For this reason the single values from the analysis and from the **dB** button agree (see Figure 1, last column).

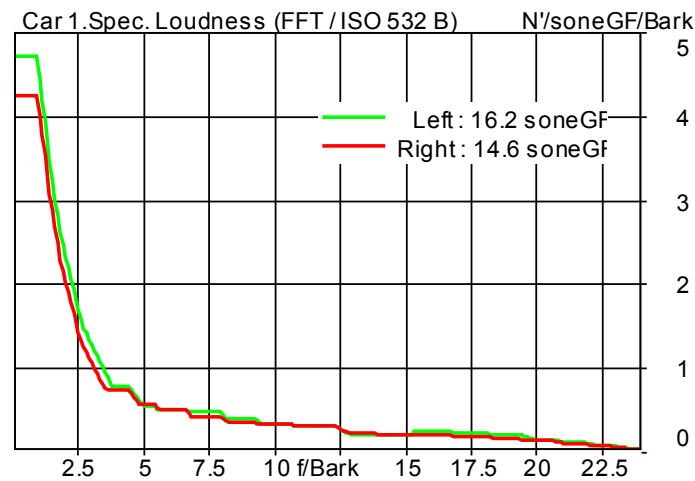


Figure 6: Single value of the loudness in a spec. loudness analysis

The single value calculation shown in figure 7 is from a time-dependent loudness analysis (loudness vs. time). For this analysis a number of loudness analyses are carried out successively and the results are displayed in the diagram as loudness as a function of time. The single value is determined via arithmetical averaging of the loudness values indicated in the diagram except as noted earlier in the method DIN 45631 (please see below). The number of loudness values is specified by the settings on the properties dialog of the analysis. That means for this case as

well, that different settings on the properties dialog may lead to different single values in the diagram.

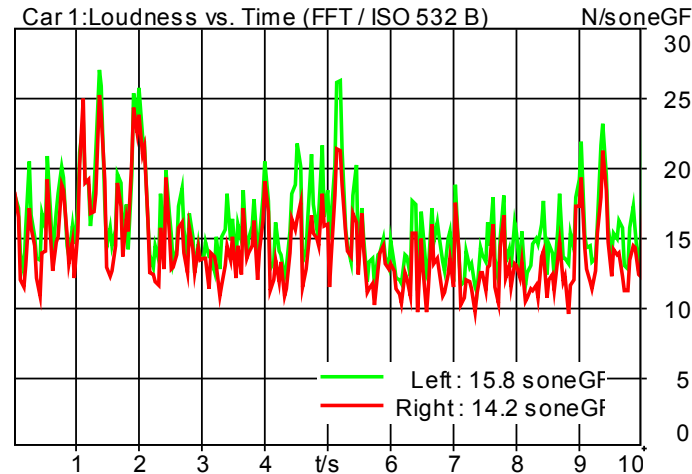


Figure 7: Single value of the loudness in a loudness vs. time analysis (Loudness method FFT / ISO 532 B)

A significant difference for the single value calculation of loudness occurs if the loudness method „DIN 45631“ is selected in the Properties Dialog. With this setting the diagram legend shows the N5 values as recommended in the standard. I. e., ArtemiS does not calculate the average value, but the value that is exceeded in 5% of the signal duration (5% percentile value). Figure 8 shows an example.

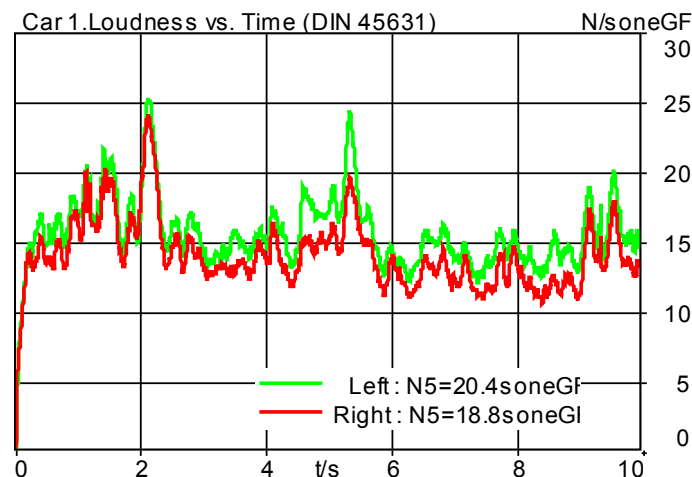


Figure 8: Single value of the loudness in a loudness vs. time analysis (Loudness method DIN 45631)

Further Analysis

In an analysis not made versus time but versus another variable, such as speed, the averaging is versus the reference variable, whose step size is also a factor. This may lead to deviations in the output of the analysis single values in comparison to the **dB** button result.

Conclusion

Figure 9 displays the difference between the calculation of the single value of level analysis with the **dB** button and with the single value function. In determining the single value with the **dB** button, the quadratic mean of each sample of the time signal is calculated and then the level calculation with the single value is given. This value is also designated as “equivalent continuous sound pressure level”.

For analysis results calculated in a Project, the single value function is selected from the diagram. In order to obtain the single value of the level, e.g. the analysis of level vs. time or FFT (average) has to be on display in a diagram.

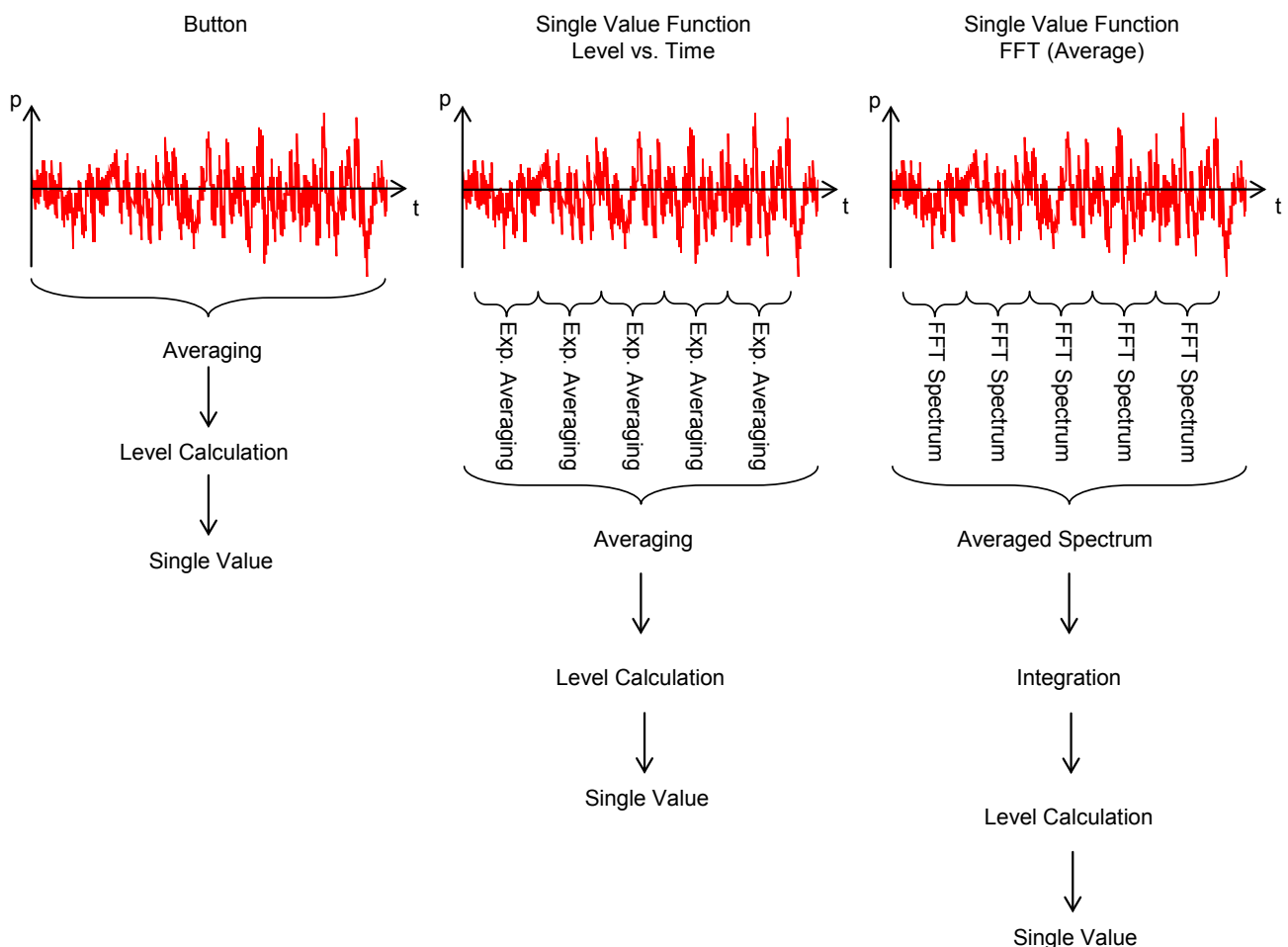


Figure 9: Schematic depiction of the calculation of a single value of the level

In using the analysis Level vs. Time the signal is initially exponentially averaged (integrated) via the time constant selected from the property page. The values thus filtered are then averaged after squaring to form a single value and can further be converted into a single value of the level. The difference relative to calculation with the **dB** button can be found in the preceding integration. Basically the difference is more noticeable the shorter the signal that needs to be analyzed in relation to the time evaluation constant. In the FFT (average) analysis in accordance with the data given on the Properties dialog, several FFT spectra are averaged. The sound pressure values of the averaged spectrum are squared for calculating the single value of the level, then

integrated over the total frequency range, and then converted into a dB value. In this kind of calculation deviations may occur due to the selected windowing and overlap.

Figure 10 shows the procedure for determining a single value of loudness via the method „FFT / ISO 532 B“. The methods of the **dB** button and single value function differ for this analysis as well. To calculate a single value by means of the **dB** button, first the averaged 3rd octave spectrum is created, then the total loudness is determined in accordance with the ISO 532 B standard.

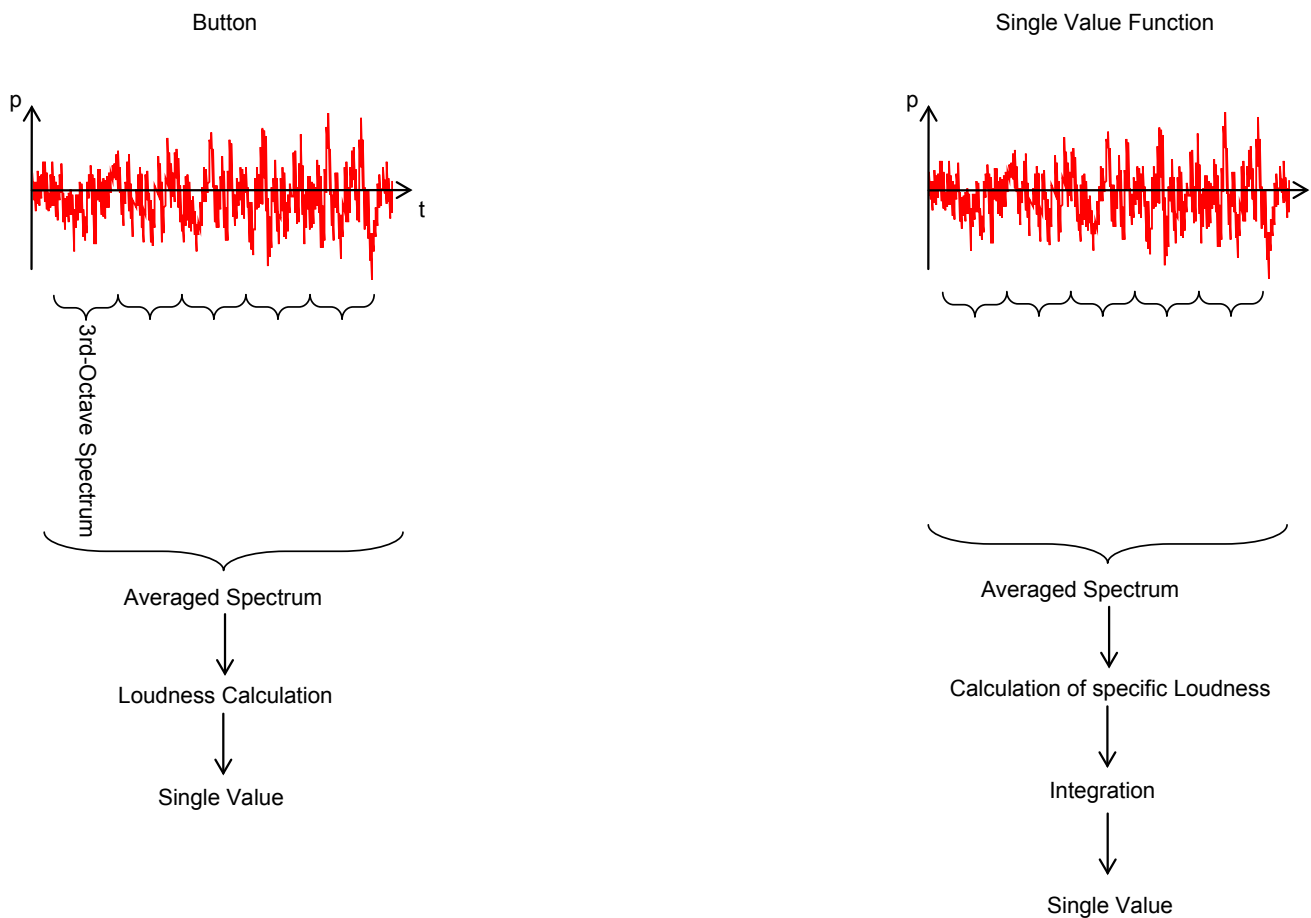


Figure 10: Schematic depiction of the calculation of a single value of loudness

In contrast, when using the analysis Loudness vs. Time a loudness value is determined for each calculated 3rd octave spectrum and then the averaging takes place. The analysis Specific Loudness on the other hand is based upon an averaged 3rd octave spectrum, from which the loudness is calculated. The single value result obtained in this analysis therefore corresponds well with the **dB** button analysis.

For time-varying sounds, a single value which cannot consider the variances may lead to misinterpretations. In general, calculating a single value for non-stationary sound via the single value function from a loudness vs. time diagram is more appropriate. Thus the shape of the curve can be considered as well in order to verify whether the single value represents the signal correctly.

Note

For the calculations presented in this application note you will need the ArtemiS Basic version (Code 4600). Moreover, the ArtemiS Psychoacoustics Module, ATP 02 (Code 4602), is required for calculating loudness single values within a diagram.

Do you have any questions or remarks? Please write to: imke.hauswirth@head-acoustics.de.
We look forward to receiving your response!