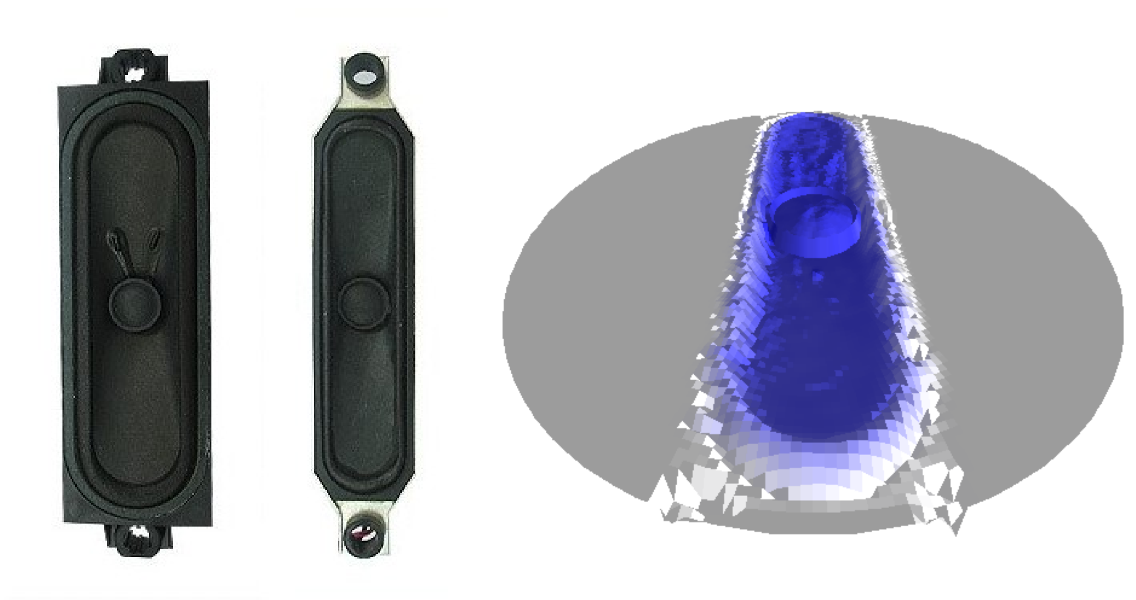
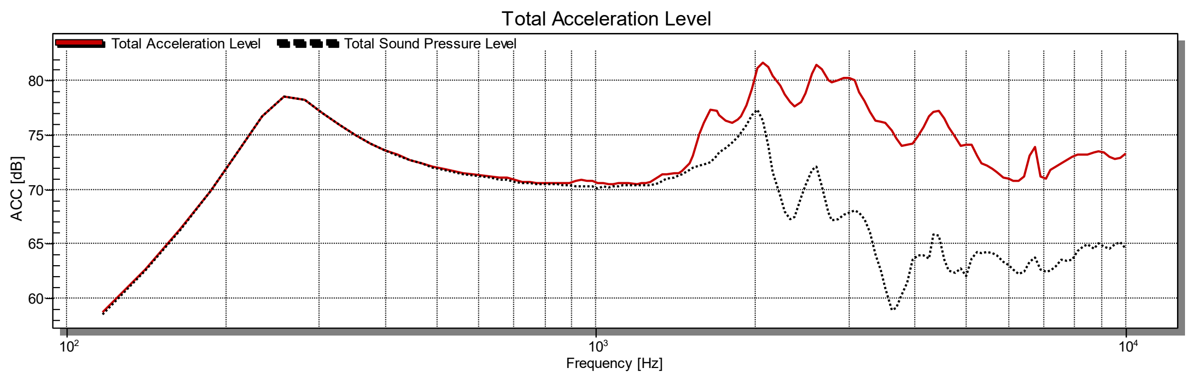
Scanning Rectangular Speakers **AN 30**

Application Note to the KLIPPEL R&D SYSTEM

Rectangular speakers are used where the space for placing loudspeakers is limited or a certain non-uniform directivity pattern shall be achieved, i.e. in flat television and display devices. The vibration and radiation properties of these speakers are more complex than for axial-symmetrical transducers. A vibration scanning measurement can help to identify the vibration modes and evaluate their influence on the sound radiation.

That Application Note gives step-by-step instructions how to perform a vibration measurement with the *Klippel Scanning System* on rectangular drivers. It gives valuable hints how to find a good setup in order to obtain optimal result data in short measurement time.





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Requirements

Klippel Scanning System

The Scanning Vibrometer (SCN) performs a non-contact measurement of the mechanical vibration and the geometry data of cones, diaphragms, panels and enclosures, see SCN Specification [1].

For vibration measurements of rectangular speakers it is recommended to use a *Klippel Scanning System Version 2.0* or newer.

Features:

Measure geometry and mechanical vibration of the transducer

Visualize the vibration behavior

Show contribution to sound pressure output

Predict directivity pattern

Separate radial and circular modes

Analyze actively radiating cone regions

Detect loudspeaker defects

Start Up

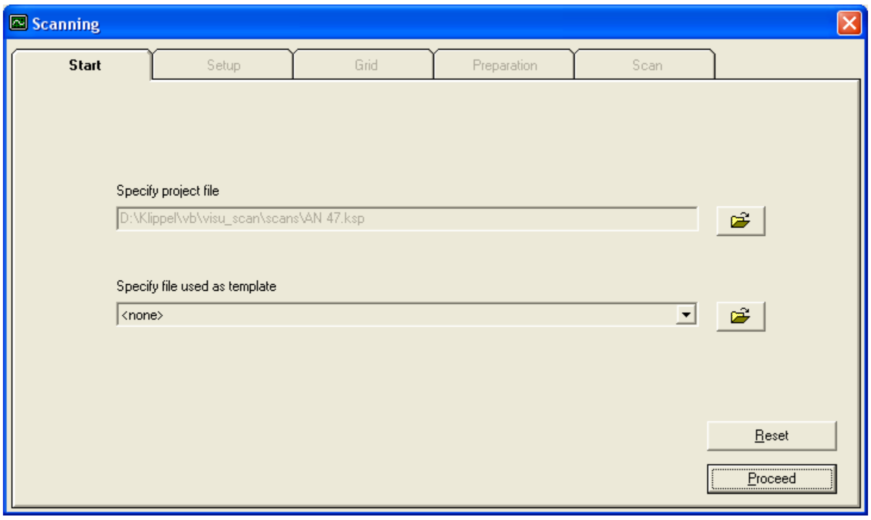
To perform a scanning measurement the following equipment is required:

Install the *Klippel Scanning System 2.0* software on your computer

Setup the Scanning System according to the instruction given in the Manual [2]

The setup of a new scan can be started by selecting **Perform scan…** in the **File** menu of the *Klippel Scanning System*.

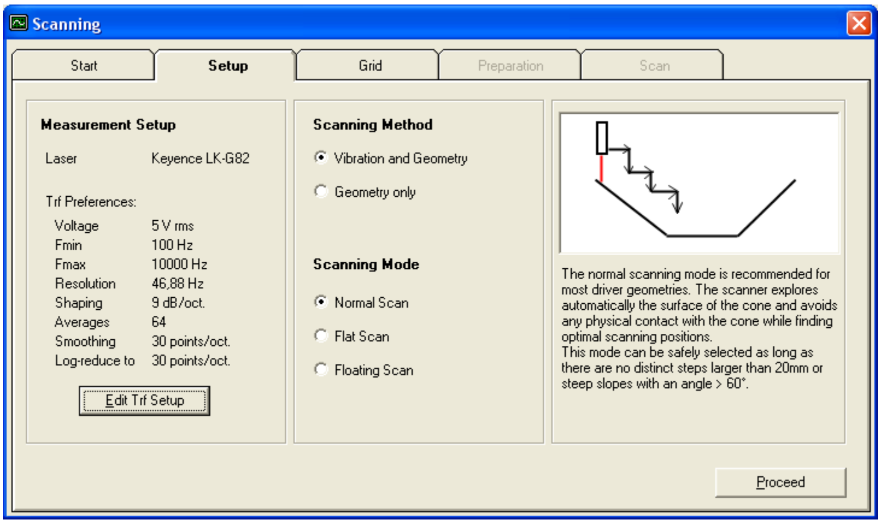
After the initialization steps a new scanning project can be started. Specify a file name for the project file and **Proceed**



TRF Setup

Perform a Test Measurement

The *Klippel TRF Module* performs the actual vibration measurement on the radiator's surface. The setup of the vibration measurement has to be adapted to the specific driver. Change the **Measurement Setup** by clicking on the Button **Edit Trf Setup.**

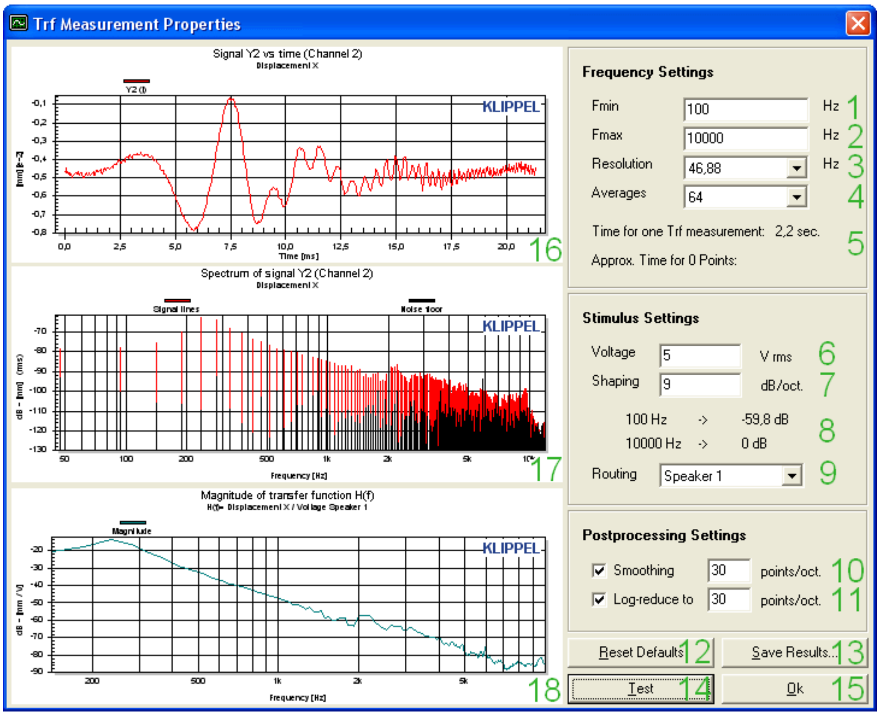


A first test measurement of the driver is advisable to find a good TRF measurement setup.

Place the speaker on the turntable and connect the clamps to the speaker terminals. For rectangular drivers it is recommended to align the longer side of the driver towards zero degree as indicated on the turntable.

Use the Motor Control device to adjust the Laser to point on a representative spot in the center of the cone. Adjust the distance of the Laser until the green OK LED indicates a valid laser signal.

Press the **Test (14)** Button in the TRF dialog to launch a vibration measurement.



Frequency Settings

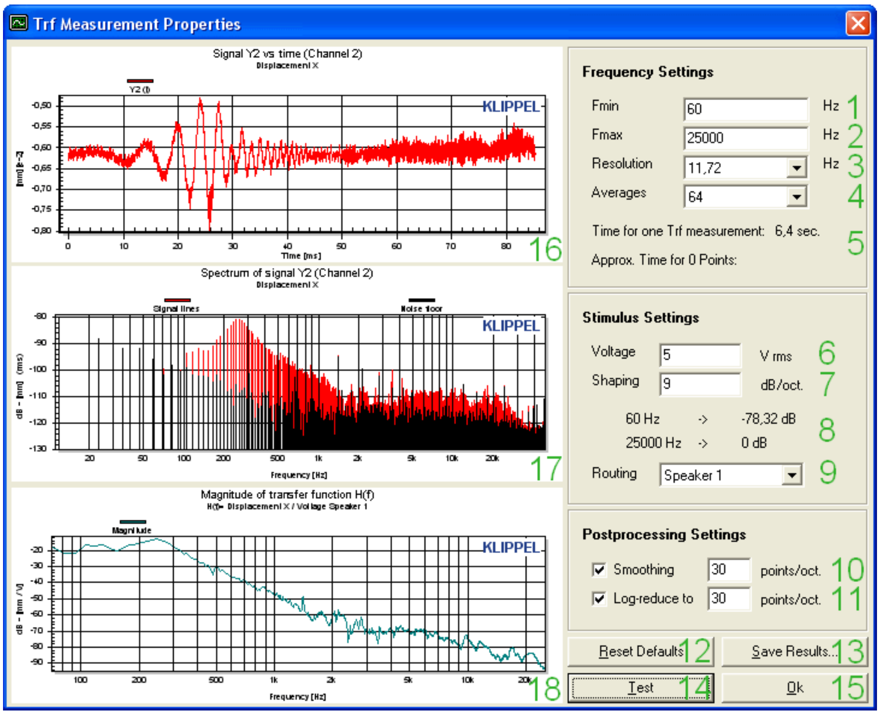
The test measurement is a good starting point for improving the settings. Adopt the frequency settings now to the specific loudspeaker:

The Start Frequency **Fmin (1)** should be about 2 octaves below the resonance frequency of the driver

The End Frequency **Fmax (2)** should be as high as the expected working range of the driver

The Frequency **Resolution (3)** and the number of **Averages (4)** are good parameters for fine-tuning the signal quality of the measurement in interaction with the measurement time, see below. For the next measurement increase the Resolution (means finer resolution), i.e. **Resolution** = 11Hz

Perform another test measurement.

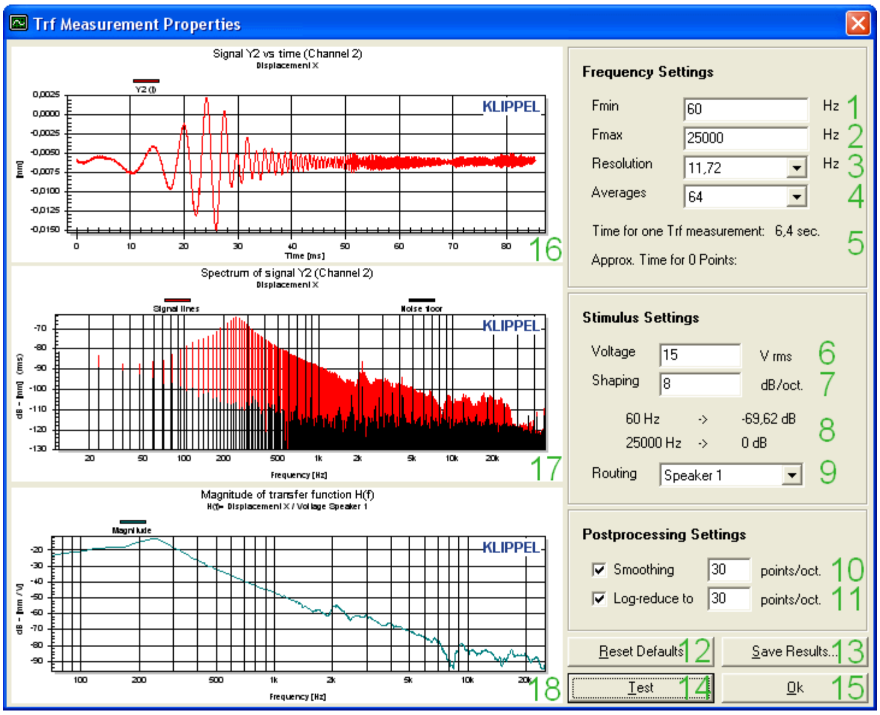


You can see that the signal to noise ratio (SNR) in the **Displacement Spectrum (17)** has decreased. That is due to the applied stimulus shaping. The given **Voltage (5)** input is applied at the highest frequency **Fmax (5)** and reduced towards lower frequency **Fmin (1)** according to the specified **Shaping (7)**. Because Fmax has increased now from 10kHz to 25kHz the actually applied voltage at low frequencies has decreased.

Some Keyence Laser heads will show a smaller operation range for measurements above 10kHz, please consult the Specification of the used Laser [1].

Stimulus Settings

Increase the voltage until the SNR close to the highest measurement frequency is more that at least 15dB. To improve the SNR at mid and low frequencies the **Stimulus Shaping (7)** can be reduced.



The setting of the stimulus voltage is important to get a good SNR. You can safely increase the voltage and reduce the shaping as long as the actual displacement as shown in the **Displacement Chart (16)** is small enough.

Trade-off between measurement time and SNR

To get optimal signal properties in short measurement time, the following rules are helpful:

Doubling the number of averages increases the SNR by 3dB over the complete frequency range, while doubling the measurement time. a moderate number of averaging is recommended. Extensive averaging will only give modest improvement in SNR but prolongs the measurement time significantly.

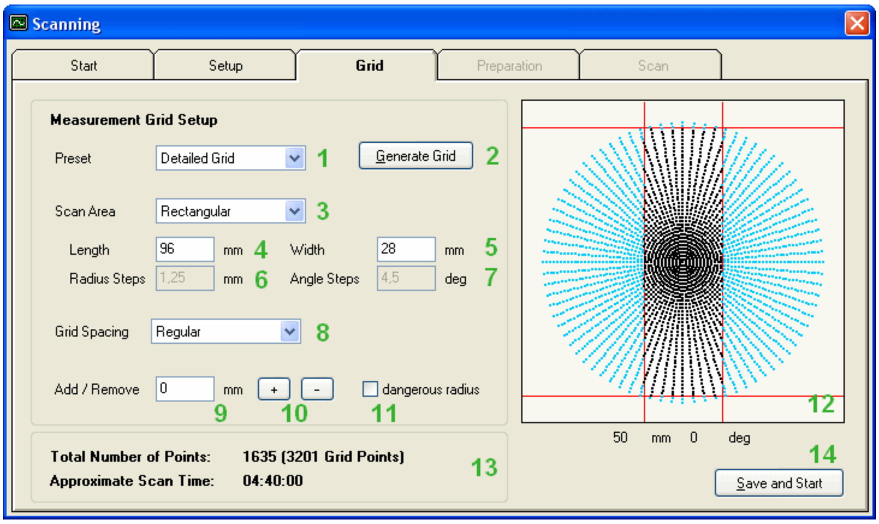
Increasing the frequency resolution will improve the SNR especially at high frequencies because the smoothing in frequency domain will combine more FFT bins to a measurement point on the logarithmic frequency scale. For low frequencies the SNR will only improve when the resolution is finer than the start frequency **Fmin (1)** divided by the number of **Smoothing points per octave (11).**

A higher frequency resolution can also result in a better separation of low frequency vibration modes.

Measurement Grid Setup

Rectangular Grid

The definition of a rectangular **Scan Area (3)** helps to confine the scanning on the actual driver surface.

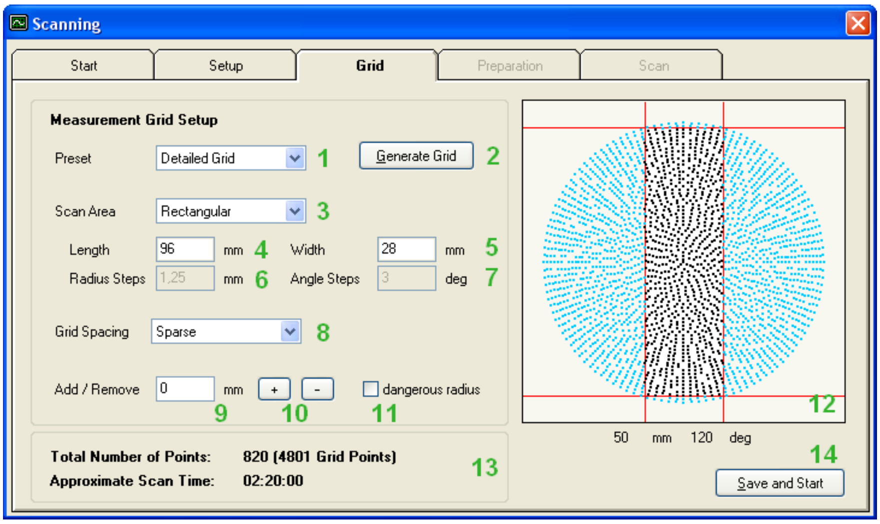


It is possible to enter the Length **(4)** and **Width (5)** of the driver and the grid points outside of that rectangle will not be measured.

The Klippel Scanning System 2.0 is required for supporting rectangular scan areas.

Sparse Grid Spacing

For rectangular drivers it is often better to change the **Grid Spacing (8)** to Sparse to achieve a more regular measurement point placement.



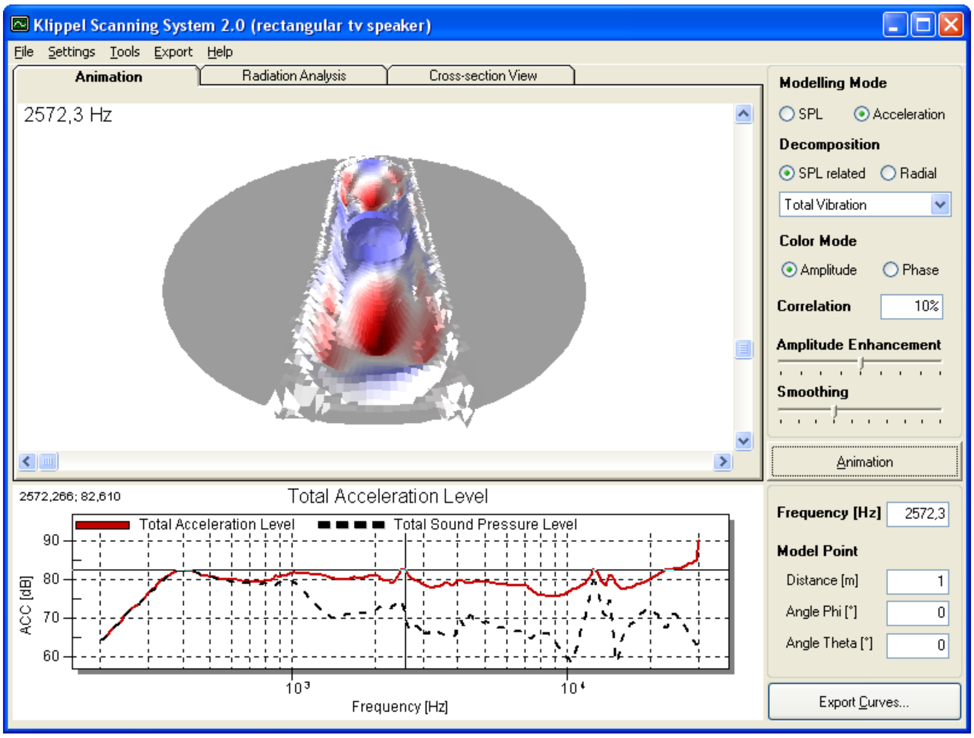
Now it is possible to increase the grid density again by switching to **Manual Grid Preset (1)** and reduce the **Radial Steps (6)** and **Angle Steps (7)** until the desired number of measurement points and scan time is reached.

A number of about 400 regularly placed measurement points is perfectly sufficient for a complete vibration and radiation analysis of a rectangular driver. For high quality resolution of the vibration shapes we recommend to specify about 1000 measurement points or more in case the scanning time is of less importance.

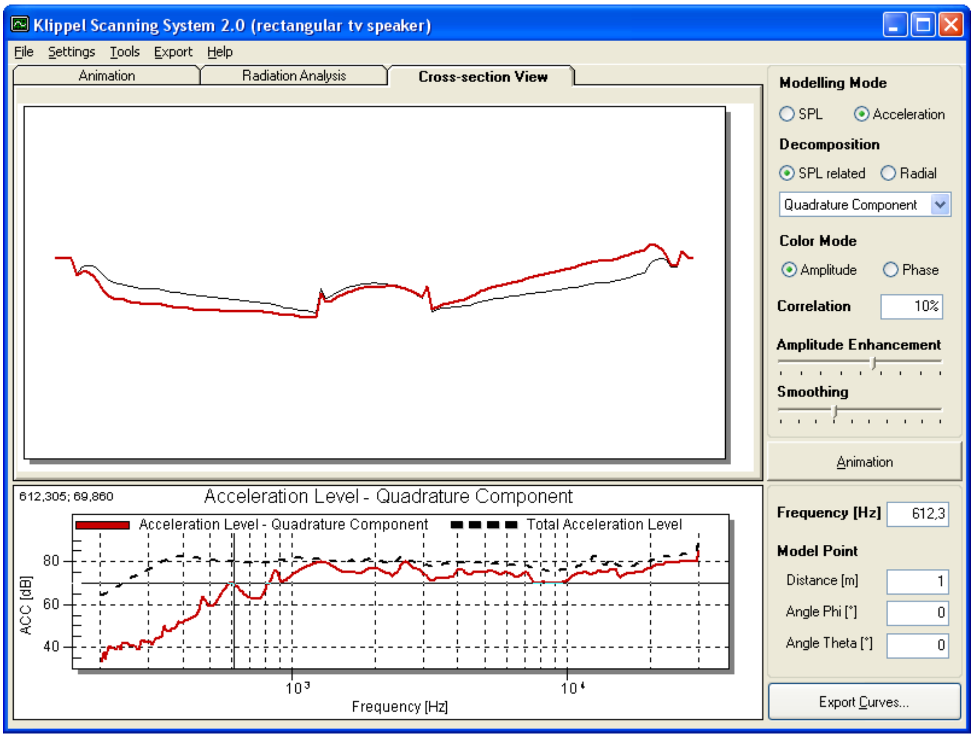
Interpretation of the Results

Vibration Analysis

The vibration analysis of rectangular cones is similar to circular cone, see also paper [5] for detailed information.



The vibration behavior can be studied over the complete measured frequency range. Peaks in the accumulated acceleration level curve indicate distinct vibration modes.

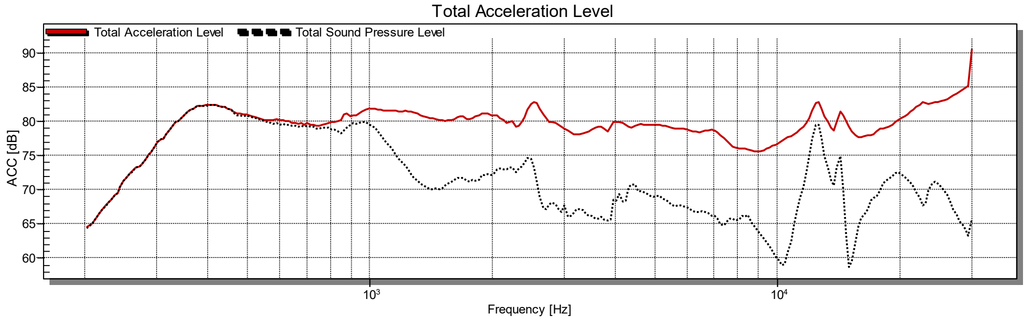


Peaks in the quadrature component curve of the acceleration level indicate vibration modes which do not contribute to the sound pressure output at the selected observing point in the far field, especially rocking motion at lower frequencies.

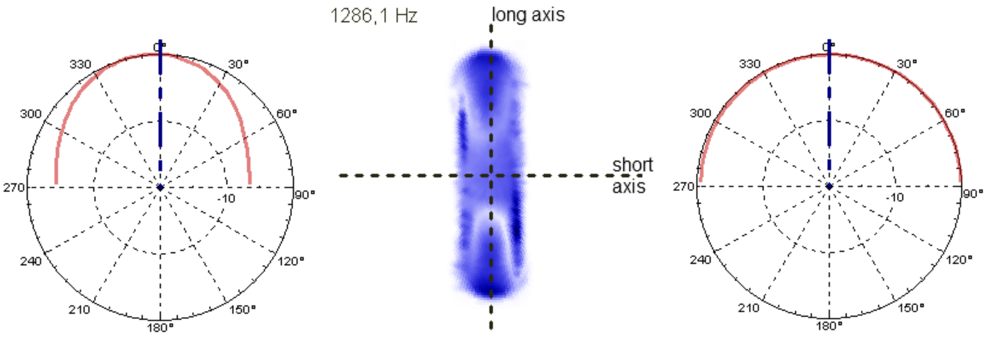
A decomposition into radial and circumferential vibration components is not applicable because of the asymmetric cone shape.

Radiation Analysis

Strong dips in the frequency response are usually caused by a contrary vibration pattern, where the radiated volume flows of two opposing vibrating areas are partly canceling out each other, as seen in the sound pressure graph below at about 10kHz.



For rectangular drivers it is especially interesting to compare the directivity pattern along the two cone axes.



long axis directivity

short axis directivity

See also Application Note 31 [3] and the listed paper [5] for further information.

More Information

Software Documentation

[1] Specification of the Klippel Scanning System, see www.klippel.de

[2] Manual of the Klippel Scanning System, included in the software installation

Related Application Notes

[3] AN31 – Cone Vibration and Radiation Analysis

Papers

[4] W. Klippel, J. Schlechter, "Distributed Mechanical Parameters of Loudspeakers (Part 1 Measurement), J. of Audio Eng. Soc. 57, No. 9, pp. 500-511 (2009 Sept.)

[5] W. Klippel, J. Schlechter, "Distributed Mechanical Parameters of Loudspeakers (Part 2 Diagnostics), J. of Audio Eng. Soc. 57, No. 9, pp. 696-708 (2009 Sept.)

updated December 19, 2022

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