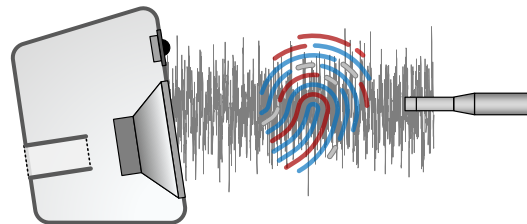
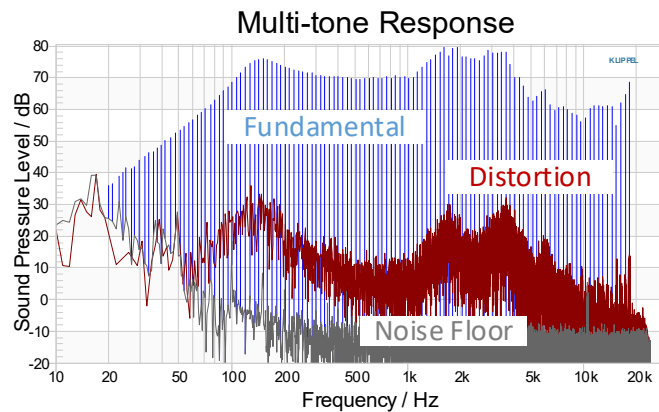


## FEATURES

- Multi-tone fundamental and distortion measurements
- SPL Max and max. voltage according to IEC 60268-21 [1]
- Continuous Max. SPL related to ANSI/CEA-2010-B [2] and ANSI/CEA-2034 [3].
- Thermal compression
- Variable measurement and cooling time durations

## BENEFITS

- Measurement of wireless, active and passive speakers
- Get acoustic “Fingerprint”
- Flexibility on stimulus and threshold setup
- Protection limits to avoid the DUT destruction
- Temperature protection



## DESCRIPTION

The *MTON Multi-tone Measurement* is a Klippel RnD module which provides a complete measurement of the device under test (DUT) using a multi-tone stimulus. MTON module offers different measurement modes to provide a high flexibility of measurement procedures.

While the *Single Measurement* mode performs a single multi-tone measurement, the *Multiple Measurements* mode offers an automatic test sequence to obtain the operation limits of the DUT related to mechanical and thermal compression as well as multi-tone distortion.

This flexibility in the threshold and stimulus configuration allows the MTON module to pinpoint the  $SPL_{max}$  according to IEC 60268-21[1] as well as the continuous max SPL (ANSI/CEA-2010-B [2] and ANSI/CEA-2034 [3]) among other standard measurements.

**CONTENT**

- 1 Overview ..... 3
- 2 Examples ..... 4
- 3 Requirements ..... 6
- 4 Input ..... 6
- 5 Output ..... 7
- 6 References ..... 13

1 Overview

1.1 Principle

Objective

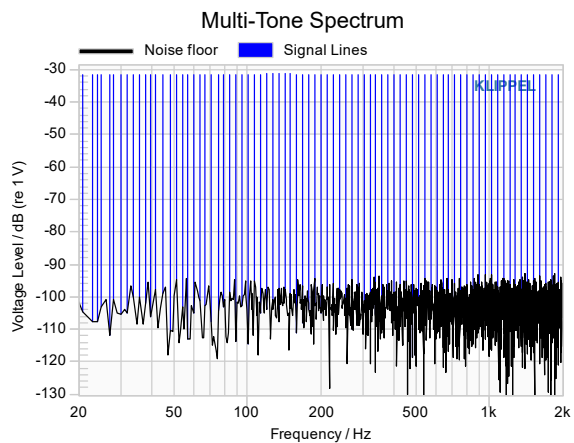
The main objective of MTON module is to provide a complete and flexible measurement environment using a multi-tone stimulus. Single values as SPL, voltage at DUT terminals and maximum displacement of voice coil, as well as result curves as multi-tone distortion, transfer function and compression are calculated.

Excitation Signal

The stimulus used during the measurement is a sparse multi-tone complex spaced logarithmically on frequency. Frequency range, frequency resolution and stimulus shaping among other parameters may be specified by the user.

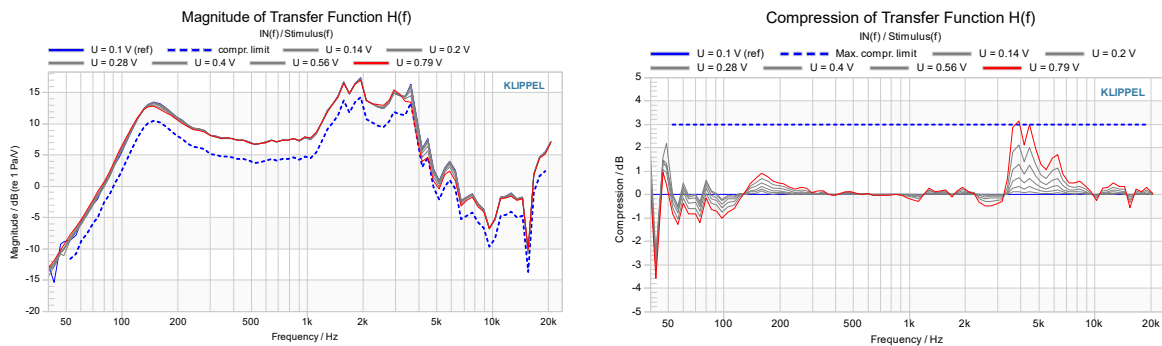
The use of a sparse multi-tone complex signal to excite the system allows the separation and characterization of distortion, which can be used to define a threshold to avoid the device destruction. Moreover, the thermal compression suffered by the device under test can be calculated, since increase of temperature leads to increasing DC-resistance.

In addition, a dense multi-tone signal similar to white noise is provided by MTON. The available shaping curves offer the stimulus characteristics required for several standards as well as pink and white noise spectrum for both sparse and dense multi-tone signals.

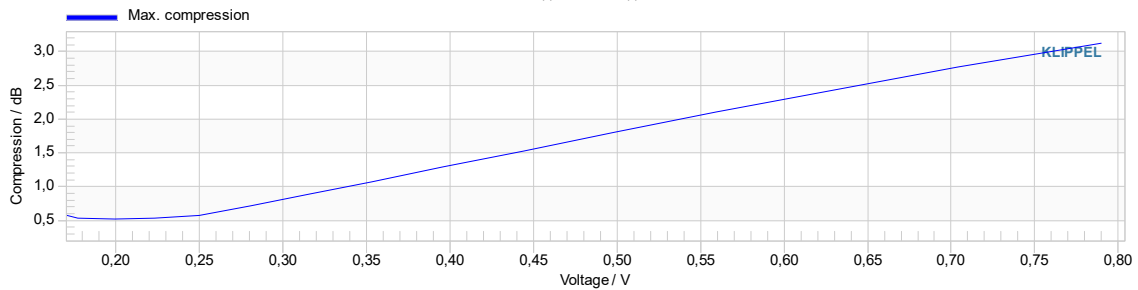


## 2 Examples

### 2.1 Compression of transfer function

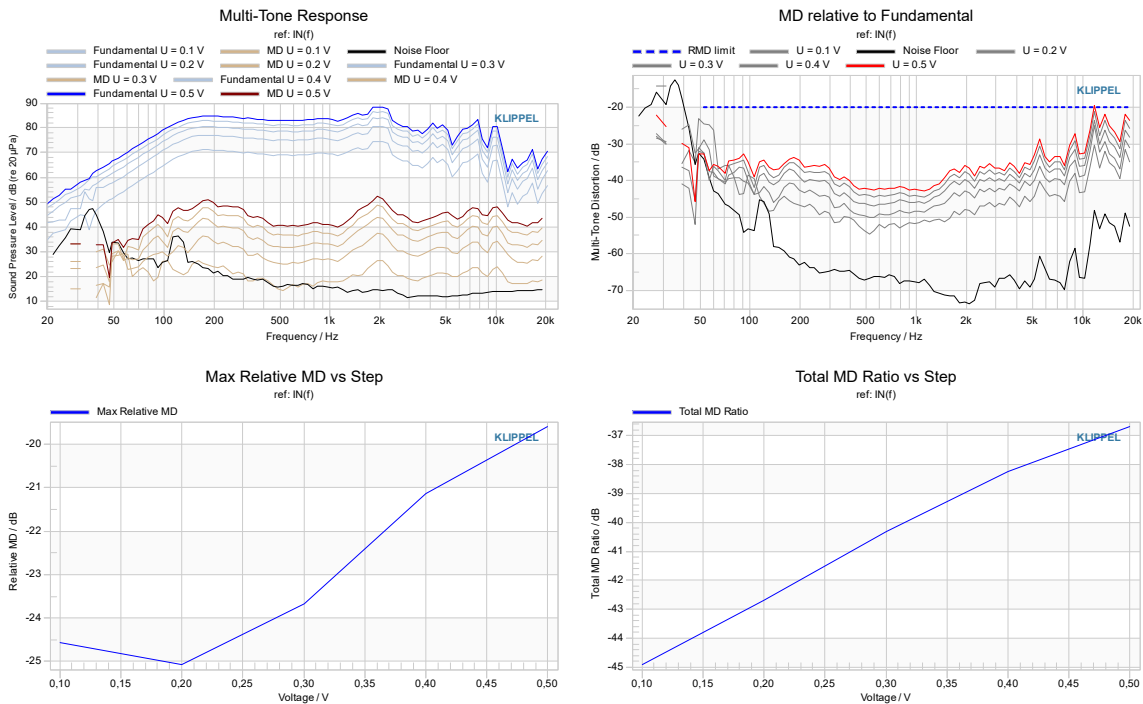


Compression of H(f) vs Measurement  
IN(f) / Stimulus(f)



The compression is calculated from the measured transfer functions using the first measurement as reference. Measurement voltage increases automatically until the user defined compression threshold (in the example 3 dB) is reached. The results of last measurement are shown in red color to emphasize the threshold overcoming.

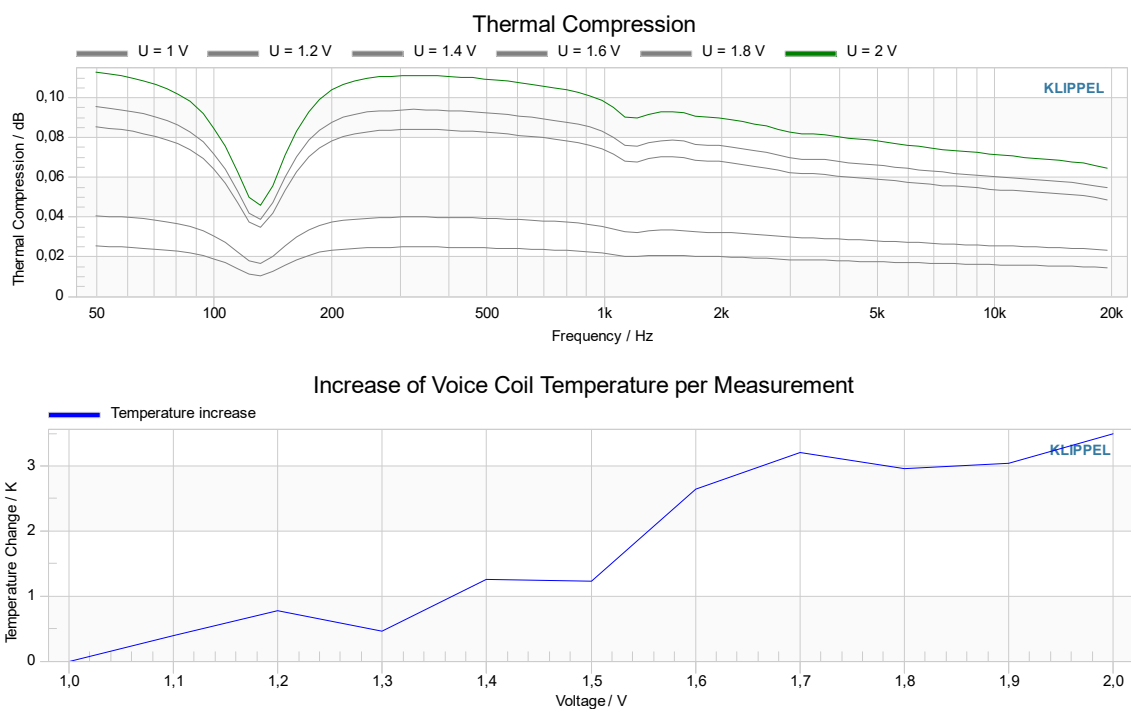
### 2.2 Multi-tone distortion



Multi-tone response and distortion curves as well as the total multi-tone distortion ratio are evaluated for the input signal selected by the user. Two different calculation methods can be selected to obtain the relative multi-tone distortion results:


- Band Level relative to Fundamental
- Smoothed relative to Average Level

### 2.3 Thermal compression / Temperature increase



Thermal compression can be measured electrically if the Klippel Analyzer (KA3, DA) is connected to the speaker terminals. This measure provides a heating threshold based on the increase of voice coil temperature.

### 3 Requirements

3.1 Hardware			SPEC
Analyzer		The Distortion Analyzer or the Klippel Analyzer 3 are used as the hardware to perform the measurement.	H1, H3
Microphone	[optional]	Free field microphone with omnidirectional directivity characteristic over the desired measurement bandwidth.	A4
Amplifier	[optional]	KA3 Amp-Card or external audio amplifier with a flat frequency response over the desired measurement bandwidth	
Laser Displacement Sensor	[optional]	A high precision laser displacement sensor may be used to capture the membrane movement.	A2
Computer	A personal computer is required for performing the measurement.		
3.2 Software			
dB-Lab	Project Management Software of the KLIPPEL R&D SYSTEM. Requires at least version 210.820.		

### 4 Input

Parameter	Min	Typ	Max	Unit
<b>Stimulus</b>				
Min Frequency	> 0	20	F max	Hz
Max Frequency	F min	18000	0.4·f <sub>sample</sub>	
Relative Resolution	1	12	999	Points per octave
Shaping	<ul style="list-style-type: none"> <li>• 1/3 Octave Bands (R10)</li> <li>• Continuous Shaping Curve</li> <li>• Not Used</li> </ul>			
Time	0.02	1	5	s
Preloops	0	1		Stim. repetition
Averaging	1	1	256	Stim. repetition
Pause	0	0		s
<b>Limits</b>				
Max. Compression		3		dB
Max. Relative Multi-Tone Distortion		- 20		dB
		10		%
Max. Total Multi-Tone Distortion Ratio		-30		dB
		3		%

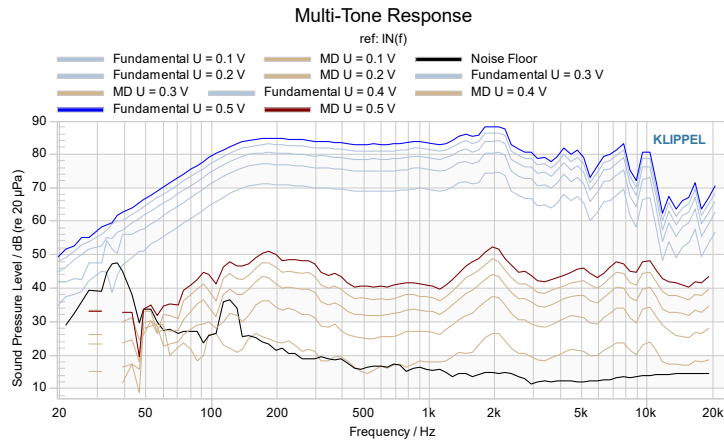
Parameter	Min	Typ	Max	Unit
Max. Increase of Voice Coil Temperature	> 0	60		K

## 5 Output

<p>Summary</p>	<p>Shows warnings and errors produced during the process, data collection table of results and stimulus properties.</p> <div data-bbox="475 539 1337 1059" style="border: 1px solid black; padding: 5px;"> <p><b>Information</b></p> <table border="1"> <tr> <td>Information</td> <td>Multi-tone distortion limit reached.</td> </tr> </table> <p><b>Results of last passed measurement</b></p> <table border="1"> <thead> <tr> <th>Parameter</th> <th>Value</th> <th>Unit</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td><math>U_{max}</math></td> <td>0.4</td> <td>V</td> <td>Root mean square of stimulus.</td> </tr> <tr> <td><math>SPL_{max}</math></td> <td>99.79</td> <td>dB</td> <td>Sum level of fundamentals in microphone signal.</td> </tr> <tr> <td><math>C_{max}</math></td> <td>0.73</td> <td>dB</td> <td>Max compression in the frequency range 53 - 19109 Hz.</td> </tr> <tr> <td><math>RMD_{max}</math></td> <td>-21.15 (8.8)</td> <td>dB (%)</td> <td>Maximum spectral multi-tone distortion ratio of microphone signal.</td> </tr> <tr> <td>TMDR</td> <td>-38.25 (1.2)</td> <td>dB (%)</td> <td>Total multi-tone distortion ratio of microphone signal.</td> </tr> </tbody> </table> <p><b>Stimulus properties</b></p> <table border="1"> <thead> <tr> <th>Parameter</th> <th>Value</th> <th>Unit</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td><math>f_{min}</math></td> <td>19.53</td> <td>Hz</td> <td>Lowest multi-tone frequency line</td> </tr> <tr> <td><math>f_{max}</math></td> <td>20480.47</td> <td>Hz</td> <td>Highest multi-tone frequency line</td> </tr> <tr> <td><math>t</math></td> <td>0.51</td> <td>s</td> <td>Signal duration</td> </tr> <tr> <td><math>K</math></td> <td>2.87</td> <td>-</td> <td>Kurtosis</td> </tr> <tr> <td><math>C</math></td> <td>11.14</td> <td>dB</td> <td>Crest factor</td> </tr> </tbody> </table> </div>	Information	Multi-tone distortion limit reached.	Parameter	Value	Unit	Description	$U_{max}$	0.4	V	Root mean square of stimulus.	$SPL_{max}$	99.79	dB	Sum level of fundamentals in microphone signal.	$C_{max}$	0.73	dB	Max compression in the frequency range 53 - 19109 Hz.	$RMD_{max}$	-21.15 (8.8)	dB (%)	Maximum spectral multi-tone distortion ratio of microphone signal.	TMDR	-38.25 (1.2)	dB (%)	Total multi-tone distortion ratio of microphone signal.	Parameter	Value	Unit	Description	$f_{min}$	19.53	Hz	Lowest multi-tone frequency line	$f_{max}$	20480.47	Hz	Highest multi-tone frequency line	$t$	0.51	s	Signal duration	$K$	2.87	-	Kurtosis	$C$	11.14	dB	Crest factor
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<p>H(f) Transfer Function Magnitude and Phase, C(f) Compression</p>	<p>Magnitude and phase of transfer function are displayed if activated. In multiple measurements mode, the compression of the transfer function measurements is calculated using the first measurement as reference. In addition, the compression limit is displayed if limit is activated.</p> <div data-bbox="395 1115 1396 1792"> <p>The figure contains three subplots:</p> <ul style="list-style-type: none"> <li><b>Magnitude of Transfer Function H(f):</b> Shows Magnitude [dB (ref Pa/V)] vs Frequency [Hz] on a log scale. Three curves are shown for U = 0.5 V (ref), U = 0.75 V, and U = 1 V. The magnitude generally increases with frequency up to about 2 kHz and then decreases.</li> <li><b>Phase of Transfer Function H(f):</b> Shows Phase [deg] vs Frequency [Hz] on a log scale. The phase starts at approximately 150 degrees at 50 Hz and decreases towards -150 degrees at 20 kHz.</li> <li><b>Compression of Transfer Function H(f):</b> Shows Compression [dB] vs Frequency [Hz] on a log scale. The compression is mostly near 0 dB, with some peaks around 5 kHz.</li> </ul> </div>																																																		

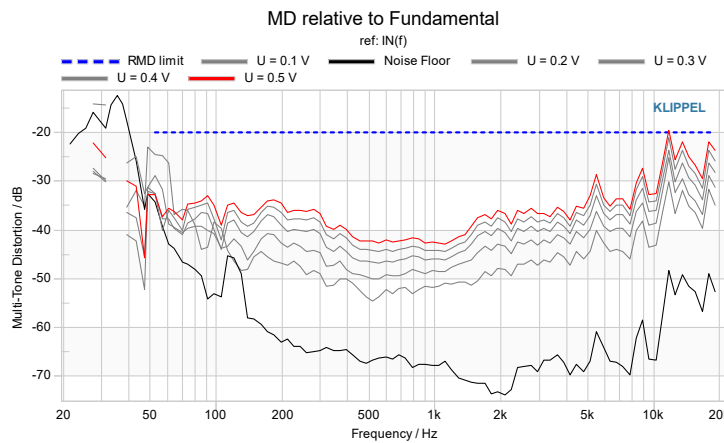
Multi-Tone Response

Graph showing absolute multi-tone fundamental and distortion curves measured, as well as noise floor curve if activated.



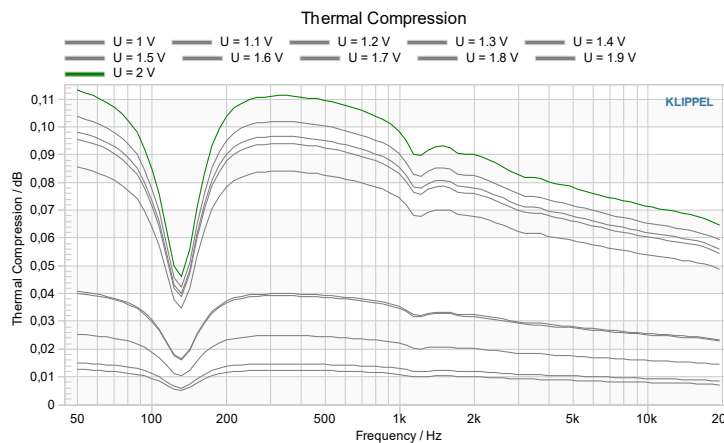
Multi-Tone Distortion

Graph showing relative multi-tone distortion curves measured. In addition, the relative multi-tone distortion curve is displayed if limit is activated.

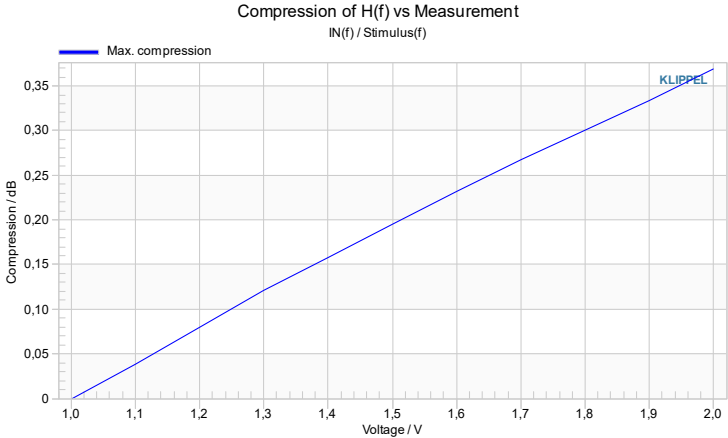
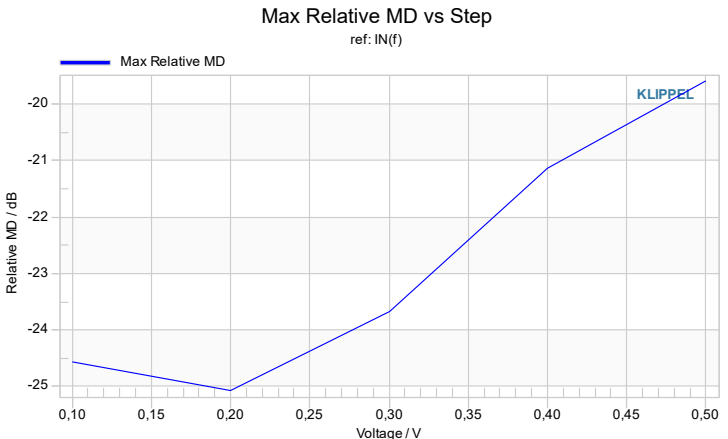
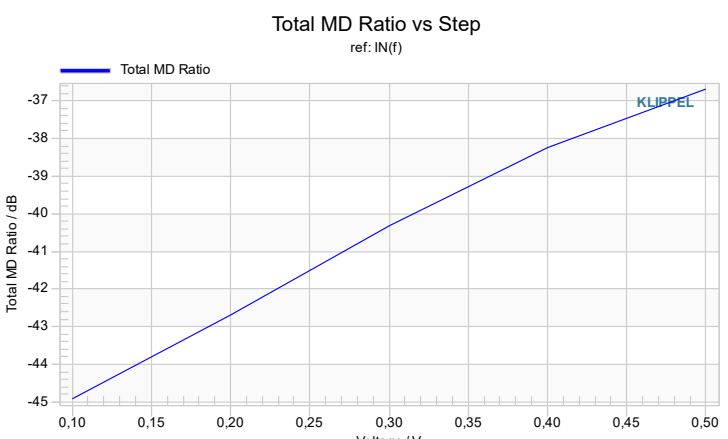


TC(f) Thermal Compression

Window showing the thermal compression measured, if resistance monitoring activated.

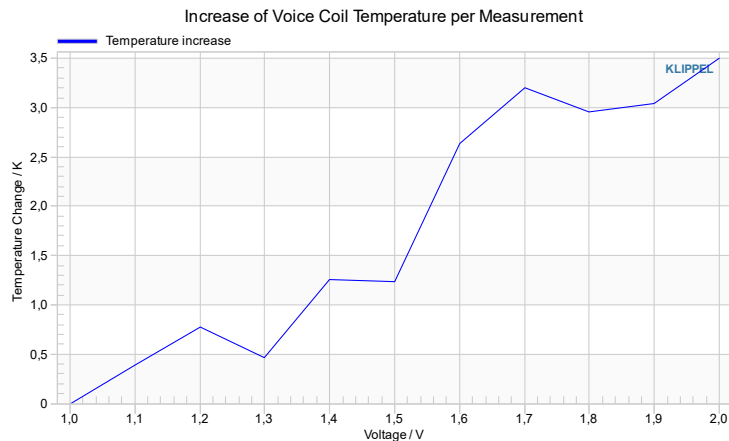




<p>Compression vs Step</p>	<p>Graph showing the maximum or mean compression of each individual measurement over the measurement voltages if transfer function is activated.</p> <p style="text-align: center;">Compression of H(f) vs Measurement IN(f) / Stimulus(f)</p> 
<p>Multi-Tone Distortion vs Step</p>	<p>Graph showing the multi-tone distortion peak of each individual measurement over the measurement voltages if multi-tone response calculation is activated.</p> <p style="text-align: center;">Max Relative MD vs Step ref: IN(f)</p> 
<p>Total MD Ratio vs Step</p>	<p>Graph showing the total multi-tone distortion ratio of each individual measurement over the measurement voltages if multi-tone response is activated.</p> <p style="text-align: center;">Total MD Ratio vs Step ref: IN(f)</p> 

$\Delta T$  Temperature Increase

Graph showing the voice coil temperature increase of each individual measurement over the measurement voltages if resistance monitoring is activated.



Sum Input

Level

Chart showing the SPL value measured over the measurement voltages if microphone signal is captured.

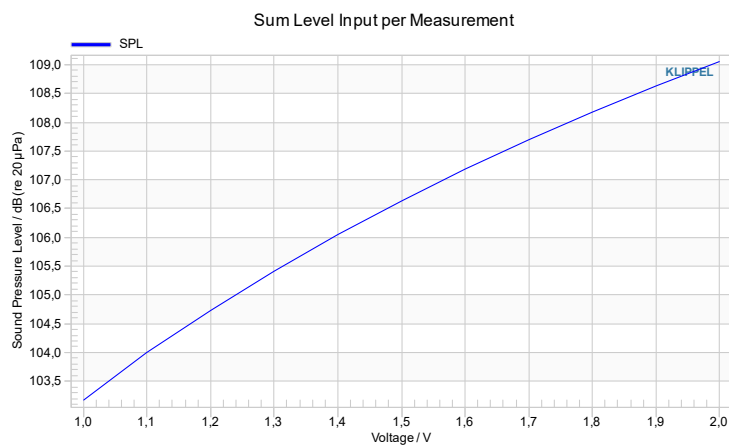


Table Detailed Results

Collect result values of all measurements.

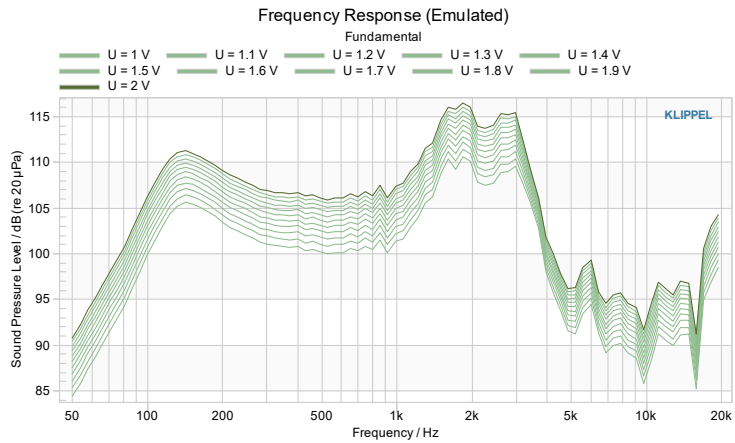
Meas.	U	SPL	$ x _{peak}$	$C_{max}$	Abs. MD <sub>max</sub>	Rel. MD <sub>max</sub>	TMDR
6	0.6 V	101.49 dB	0.41 mm	0.69 dB	53.64 dB	-19.11 dB	-35.36 dB
5	0.5 V	99.87 dB	0.44 mm	0.98 dB	50.45 dB	-20.52 dB	-36.82 dB
4	0.4 V	97.9 dB	0.33 mm	0.8 dB	47.23 dB	-22.13 dB	-38.04 dB
3	0.3 V	95.41 dB	0.32 mm	0.38 dB	43.31 dB	-24.11 dB	-39.41 dB
2	0.2 V	91.91 dB	0.31 mm	0.27 dB	42.58 dB	-27.24 dB	-40.22 dB
1	0.1 V	85.93 dB	0.31 mm	0 dB	43.06 dB	-23.02 dB	-34.74 dB

**Signal Characteristics Meas. #6 (U = 0.6V):**

Parameter	u	i	IN (Mic)	x	Description
RMS	0.53 V	0.12 A	2.37 Pa	0.11 mm	RMS value considering only AC component
DC	-	-	-	-0.69 mm	DC component
Peak	2.14 V	0.41 A	9.95 Pa	0.41 mm	Peak value considering only AC component
Bottom	-1.79 V	-0.39 A	-9.33 Pa	-0.41 mm	Bottom value considering only AC component
Abs. Peak	2.14 V	0.41 A	9.95 Pa	0.41 mm	Abs. peak value considering only AC component
Crest Factor	12.19 dB	10.96 dB	12.44 dB	11.17 dB	Crest Factor value considering only AC component
Kurtosis	2.87	2.85	3.06	2.89	Kurtosis value considering only AC component

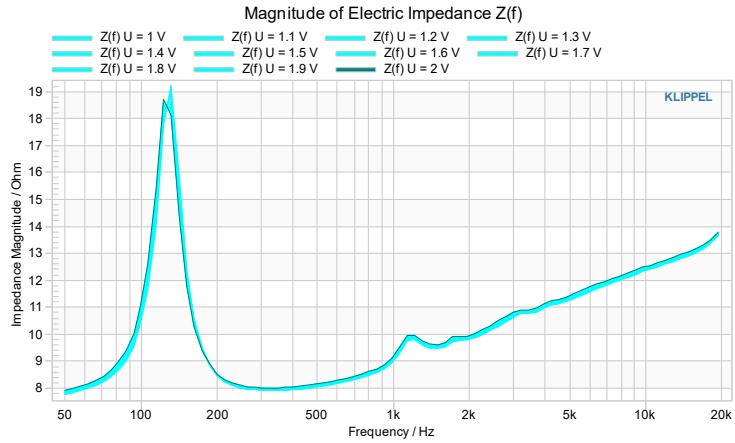
Frequency Response (Emulated)

Frequency response emulated from microphone signal is displayed.



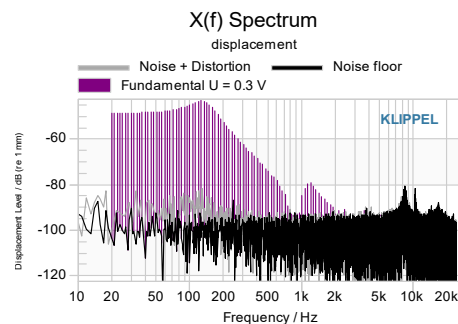
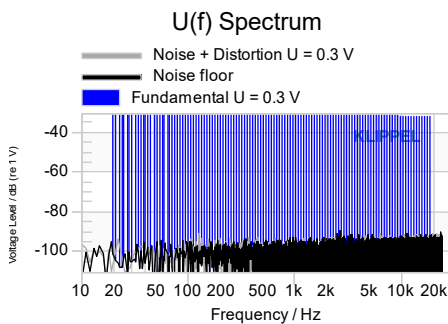
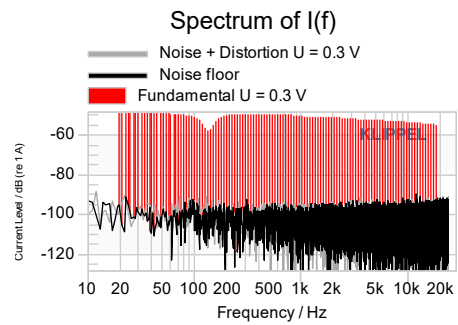
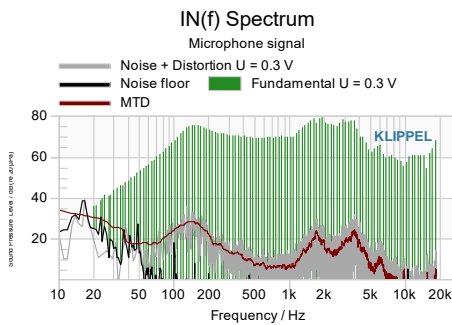
Z(f) Impedance Magnitude

Magnitude of electric impedance calculated from voltage and current measurements at terminals.



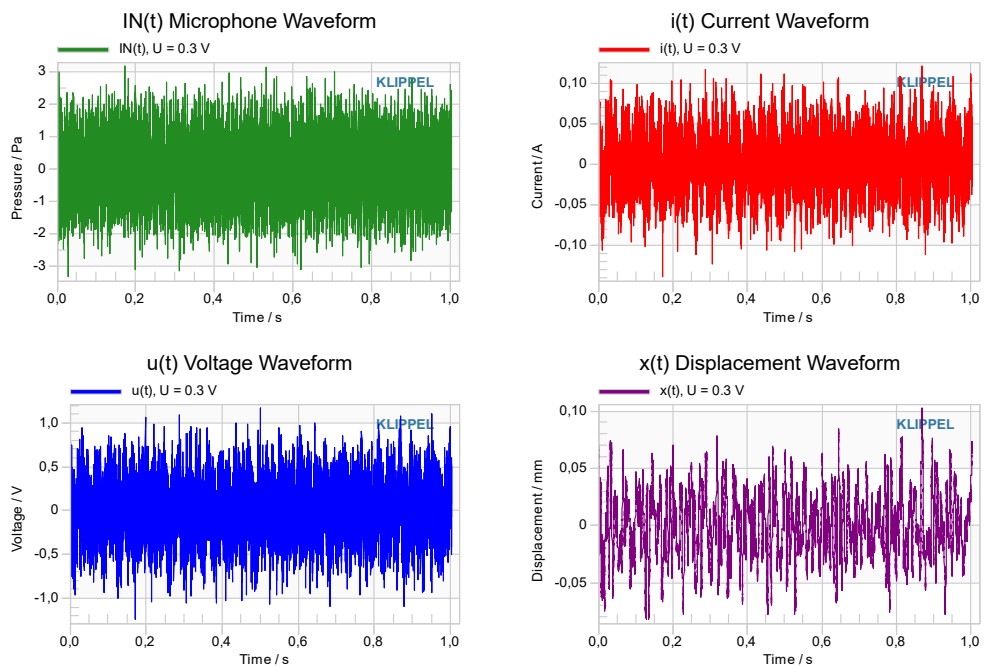
IN(f), I(f), U(f), X(f) Spectrum

Measured signals in frequency domain. Only visible if input is activated. In addition, noise + distortion and noise floor of last measurements are displayed.



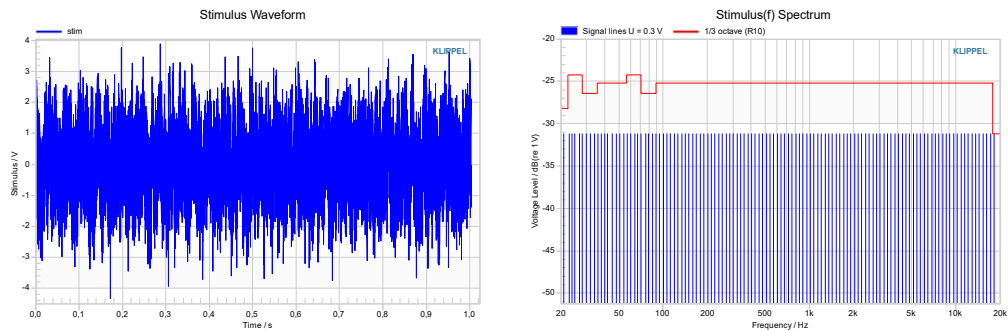
IN(f), I(t), U(t), X(t) Waveform

Measured signals in time domain. Only visible if input is activated.



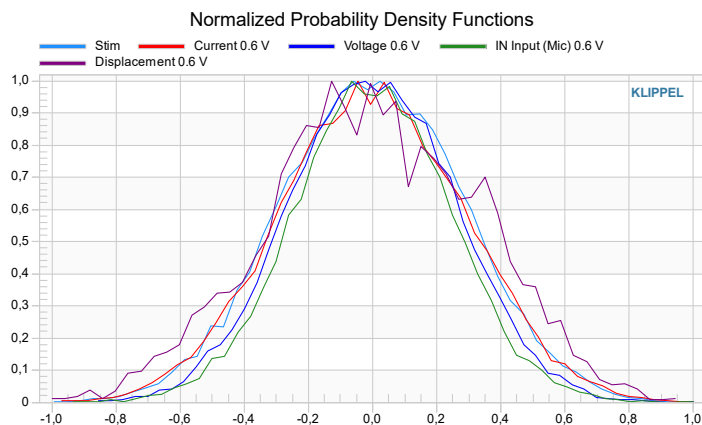
Stimulus Spectrum, waveform

Stimulus waveform and spectrum displayed as signal lines and 1/3 octave bands (R10).



PDF Signals

Normalized probability density functions of stimulus and last measured signals.



## 6 References

<b>6.1 Related Modules</b>	<a href="#">Multi-Tone Distortion Task</a> (MTD) <a href="#">Live Audio Analyzer</a> (LAA) <a href="#">Distortion Measurement</a> (DIS) <a href="#">Transfer function measurement</a> (TRF) <a href="#">Tone Burst Measurement</a> (TBM) <a href="#">In-Situ Room Compensation</a> (ISC)
<b>6.2 Manuals</b>	Multi-Tone Measurement User Manual
<b>6.3 Standards</b>	<p>[1] IEC 60268-21: "Sound system equipment – Part21: Acoustical (output-based) measurements", 2018, International Electrotechnical Commission</p> <p>[2] ANSI/CEA-2010-B: "Standard Method of Measurement for Subwoofers", 2014, Consumer Electronics Association</p> <p>[3] ANSI/CEA-2034: "Standard Method of Measurement for In-Home Loudspeakers", 2013, Consumer Electronics Association</p>
<b>6.4 Publications</b>	<a href="#">A. Taylor, "Mastering Wireless Multi-Tone Testing"</a> <a href="#">W. Klippel: Physical and Perceptual Evaluation of Electric Guitar Loudspeakers</a> Voishvillo, et. al. , "Graphing, Interpretation, and Comparison of Results of Loudspeaker Nonlinear Distortion Measurements," J. Audio Eng. Society 52, No. 4 pp. 332-357 (Apr. 2004)
<b>6.5 Application Notes</b>	AN16 <a href="#">Multi-tone Distortion Measurement</a>
<b>6.6 Web-Seminars</b>	<a href="#">Series 1, #7: Amplitude Compression – Less Output at Higher Amplitudes</a> <a href="#">Series 1, #11: Pitfalls in Testing Wireless Audio Devices</a>

Find explanations for symbols at:

<http://www.klippel.de/know-how/literature.html>

Last updated: 2022-03-11

Designs and specifications are subject to change without notice due to modifications or improvements.

