# QC – Multi-tone Distortion Task S68

Module of the KLIPPEL ANALYZER SYSTEM (QC Ver. 7, dB-Lab Ver. 212)

Document Revision 1.1

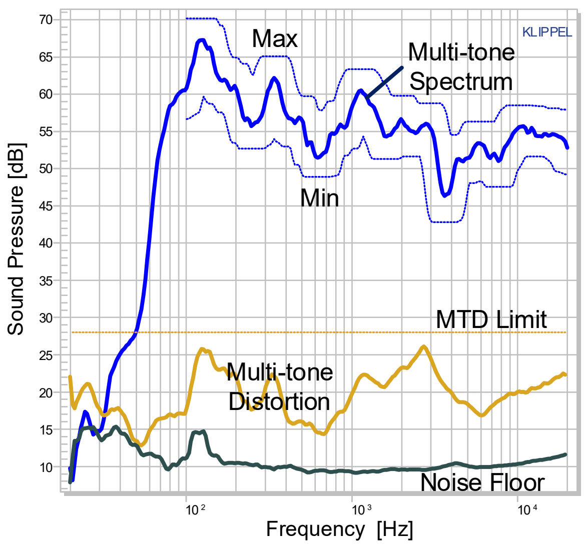
## FEATURES

- Multi-tone stimulus
- Multi-tone spectrum
- Multi-tone distortion summing harmonic and intermodulation distortion
- Analysis of input current or sound pressure
- Compliant to IEC60268-21

## BENEFITS

- „Fingerprint“ testing of speaker and sound systems
- Diagnostics using multi-tone distortion
- Ensures overall consistency of production
- Optional noise floor check

Multi-tone Task Results




## DESCRIPTION

The multi-tone distortion task is an add-on to the QC end-of-line test system. This module can be inserted as a test step (task) in any existing QC test. It is based on multi-tone test signals.

Multi-tone stimuli excite not only harmonics distortion (such as chirp signals used in SPL task) but also intermodulation distortion that provide a much more comprehensive distortion pattern than harmonics alone. Due to the higher number of excited frequencies it is not possible to separate distinct causes and symptoms which as can be done for harmonics and IM distortion analysis. In fact, multi-tone distortions are used to identify a distortion fingerprint which is a meaningful quality measure of audio products since multi-tone stimuli are quite close to normal music signal properties.

A multi-tone test can be applied to acoustic (sound pressure) and electric (input current) signals using a microphone or a Klippel Analyzer hardware (PA, KA3). This allows a separation of symptoms caused by the electro-mechanic part of the audio product (current) or includes in addition also vibration and radiation effects (sound pressure).

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| Article number | 4000-003 |

## CONTENT

# 1 Overview

## 1.1 Principle

The stimulus is a multi-tone signal. The excited frequencies are used to calculate the multi-tone spectrum curve. The response signal between excited frequencies is caused by distortion or measurement noise and is used to calculate the multi-tone distortion curve.

## 1.2 Results

**Multi-tone Spectrum**

To calculate the multi-tone spectrum the magnitudes of the excited frequencies are analyzed. The frequencies between two excited lines are caused by distortion.

**SPL:**

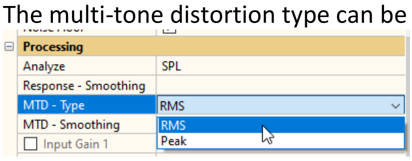
$L_{MT}(f) = 20 \cdot log(p(f_{MT}))$

**Current:**

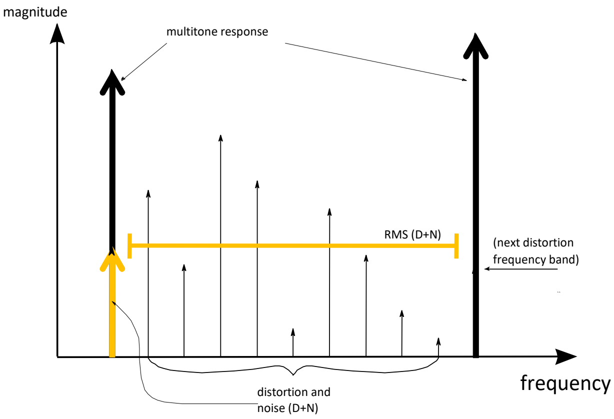
$I_{MT}(f) = 20 \cdot log(I(f_{MT}))$

**Multi-tone Distortion**

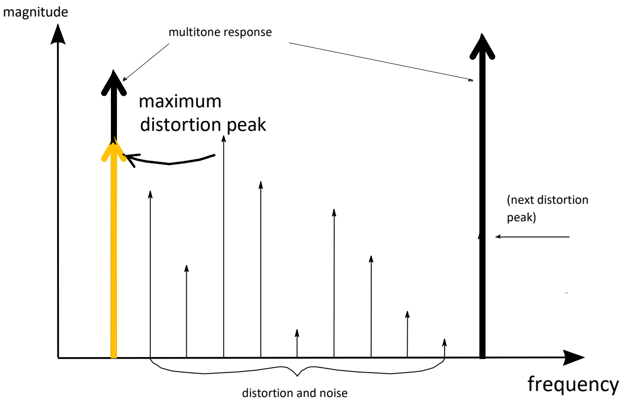
The multi-tone distortion type can be selected:




Option "RMS" sums the distortion and noise between 2 excited frequencies as rms value.




Option "Peak" yields the maximum (peak) of the distortion between two excited frequencies.




The distortion value is assigned to the lower excited frequency bin to allow better comparison and postprocessing.

**Noise floor**

A pre measurement without excitation may be optionally performed. The duration is identical to the test time and doubles the overall time for this task.

# 2 Examples

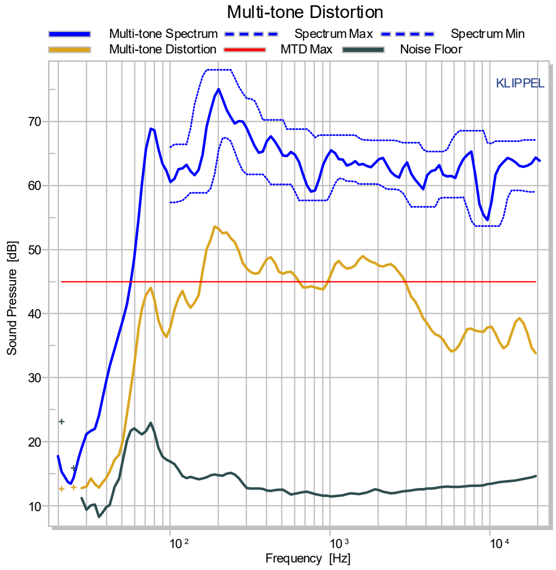
## 2.1 Example 1

**SPL Measurement**

A studio monitor was measured in a normal room in 1m distance at high level. The multitone spectrum shows the expected, almost flat response characteristics above 80Hz (blue).

The multi-tone distortion (orange) are relatively high compared to the fundamental response. A limit was chosen to ensure at least 20dB distance between distortion and fundamental. In this example the limit was violated and therefor the QC verdict was FAIL. Compared with a THD measurement it is obvious that multi-tone distortion does not decay with frequency (excursion) but are relatively constant in this case due to a dominant amount of intermodulation distortion.

The noise floor was measured as well showing a distance of >20dB to the distortion which is an indication for a reliable distortion measurement.

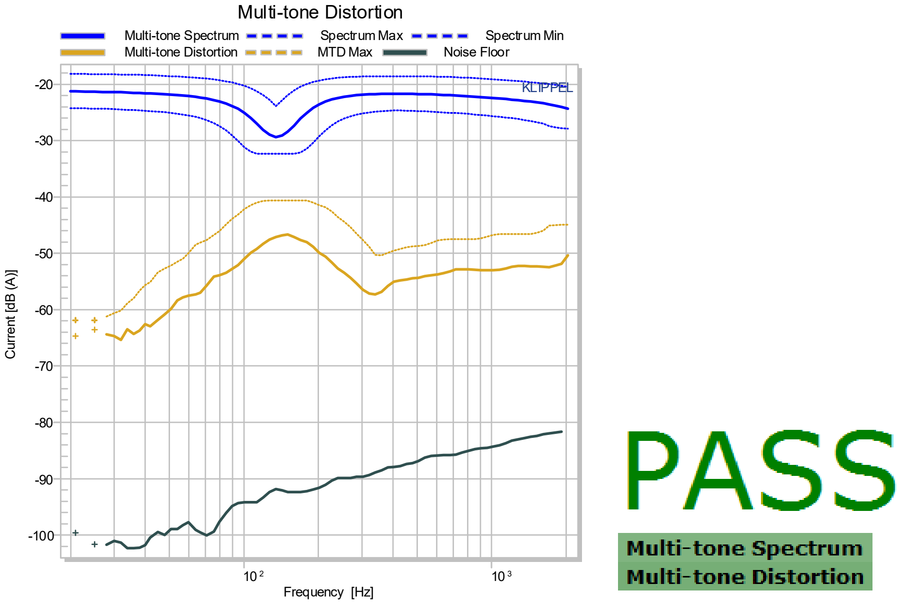



## 2.2 Example 2

Input Current Analysis

A 8‘‘woofer was tested for modulation distortion in input current. The fundamental component (blue) shows the typical dip at resonance where the impedance in high and hence the input current is low. However, at of there is usually the highest excursion. Since dominant non-linearities in transducers are depending on excursion, in this frequency range the multi-tone distortion are highest. In this example the distortion are checked against a reference DUT, which was defining the limit curves (with some headroom). The currently measured DUT did not deviate considerably from the reference and therefore the QC test returned a PASS.

Again, noise floor was sufficiently low. Acoustic disturbances are not reflected in the noise floor, which is a bonus for input current analysis.



# 3 Requirements

## 3.1 Hardware

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|---|---|
| Audio Device | For sound pressure analysis any test hardware (PA, KA3, soundcards) can be used.<br>For current analysis Klippel Hardware (PA, KA3) is required. |
| Mixed devices, Bluetooth | For mixed audio device (capture device not identical or synchronized to playback device) the multi-tone task is not recommended. A potential clock drift will deteriorate the results especially at higher frequencies and the peak distortion.<br>If a measurement under such conditions is inevitable, the test time should be chosen as short as possible (0,2s) and the bandwidth restricted to about 1-2kHz. |
| License device | A Klippel Dongle (USB) or Klippel Analyzer 3 (KA3) is required as license device. |
| Microphone | For sound pressure analysis any hardware compliant microphone can be used. |
| Test enclosure | For acoustic tests in production, a noise shielding test chamber is recommended. |

## 3.2 Software

| | |
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| QC System | QC Standard software + Multi-tone Task |
| R&D System | R&D application: The Multi-tone Task can be operated alone or in any combination with other QC tasks. |

# 4 Limitations

## 4.1 Device Under Test

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|---|---|
| Electro-acoustical transducer | Any electro-acoustical transducer (speaker) producing sound and having any signal input can be tested. |
| Electro-mechanical transducer | Any electro-mechanical transducer (shaker) may be tested as well using acceleration sensors. A laser may be used alternatively but usually the SNR of standard laser sensors based on triangulation principle is not sufficient for accurate distortion analysis. |

## 4.2 Acoustical (Sound Pressure only)

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| Noise disturbance | Controlled acoustic environment ensures consistent results. A test enclosure for QC-application is recommend.<br>Note, noise detection is not yet available. It will be added in a later revision. |

# 5 Setup

## 5.1 Setup Parameter Limits

| Parameter | Symbol | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| **STIMULUS & ACQUISITION** | | | | | |
| Frequency range | $f_{start}$, $f_{stop}$ | 0.1 | 20 | 80 k | Hz |
| Test time | $t_{test}$ | 0.2 | 0.5 | 20 | s |
| Multi-tone Resolution (logarithmic) | $R$ | 1 | 12 | 200 | frequencies / octave |
| Preloop (factor of test time) | | 0 | 0 | 20 | |

| | | | | | |
|---|---|---|---|---|---|
| Averaging (factor of test time) | | 0 | 0 | 20 | |
| **PROCESSING** | | | | | |
| Spectral Smoothing (may be disabled) | $S_{\text{Fund}}$ | 1 | Off | 99 | Part of octave |
| Multi-tone Distortion Smoothing (may be disabled) | $S_{\text{MTD}}$ | 1 | Off | 99 | Part of octave |

# 6 Results

## 6.1 Results

| Measure | Symbol | Unit | QC Limits Applicable |
|---|---|---|---|
| Multi-tone Spectrum | $L_p(f)$ | dBSPL / dB rel 1A | ✓ |
| Multi-tone Distortion (rms) | $MDS_{\text{rms}}$ | dBSPL / dB rel 1A | ✓ |
| Multi-tone Distortion (peak) | $MDS_{\text{peak}}$ | dBSPL / dB rel 1A | ✓ |
| Noise Floor | $N_{floor}$ | dBSPL / dB rel 1A | |

# 7 References

## 7.1 Related Modules

R&D:

- Multi-tone Measurement (MTON)
- Live Audio Analyzer (LAA)
- Distortion Measurement (DIS)
- Transfer function measurement (TRF)

QC:

- Sound Pressure Task (SPL)
- Spectral Analysis Task (SAN)

## 7.2 Manuals

Multi-tone Distortion Task User Manual

## 7.3 Publications

IEC 60268-21

W. Klippel: Physical and Perceptual Evaluation of Electric Guitar Loudspeakers

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)

## 7.4 Application Notes

AN16 Multi-tone Distortion Measurement

AN46 Test Enclosure for QC

Find explanations for symbols at:

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

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