

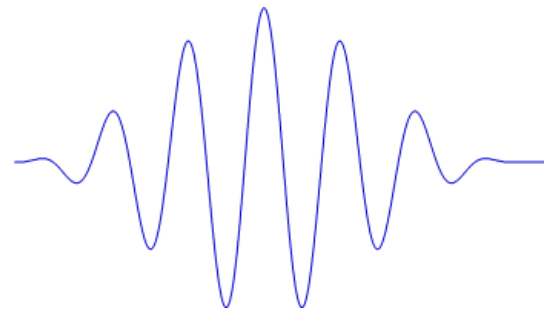
# TBM - Tone Burst Measurement (CEA 2010)

S44

Software of the KLIPPEL R&D and QC SYSTEM (Document Revision 1.8)

## FEATURES

- Maximum short-term SPL (CEA/ANSI)
- Harmonic distortion versus frequency and amplitude
- Sinusoidal transient stimulus (cycles, band-width)
- Complex compensation of sound reflections in non-anechoic environment (room)



## DESCRIPTION

The TBM Module uses a transient sinusoidal burst to measure the peak SPL and harmonic distortion versus frequency and amplitude according to Standard ANSI/CEA-2010 and ANSI/CEA-2034. If the distortion exceed a user defined threshold, the input amplitude will be not increased to prevent a damage of the device under test. A second state variable (displacement, voltage, current) can be measured simultaneously. Acoustical measurements can be performed in a non-anechoic environment by compensating the room reflections by inverse filtering of the microphone signal.

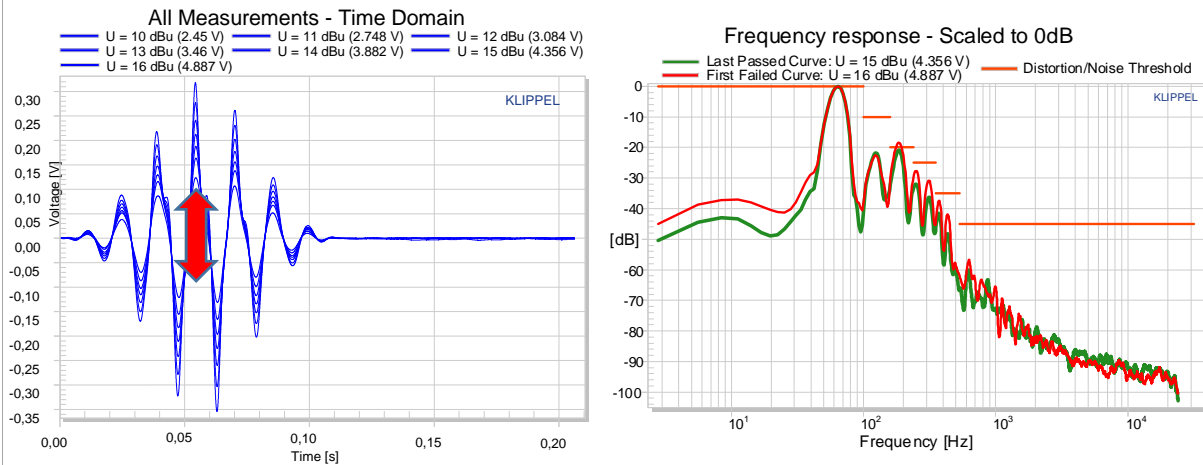
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| Article number | 1001-109 |
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## 1 Principle

The Burst measurement module is designed to run band limited burst measurements versus input voltage and frequency. The results are evaluated in frequency domain, to measure the generated distortion. A threshold curve is applied to the 1/12<sup>th</sup> octave band smoothed spectrum, to define a maximum permissible distortion generation.



For each Frequency, the voltage is increased until the threshold curve is reached. The highest voltage not reaching the threshold curve is used to calculate the peak level of this state signal (Peak SPL in CEA2010) In parallel it is possible to monitor a second state signal, to investigate the displacement or current state signal.

## 2 Components

|   |  |   |
|---|--|---|
| <b>TBM Software</b>                       | Measurement software to generate and analyse Tone Burst Measurements   |   |
| <b>2.1 Additional Components required</b> |  |   |
| <b>Analyzer</b>                           | The Distortion Analyzer or the Klippel Analyzer 3 is used as the hardware to perform the measurement.  |  |
| <b>Microphone</b>                         | A 1/4" microphone is required for sound pressure measurement in the pressure chamber.<br>Recommended Product:<br><ul style="list-style-type: none"> <li>MIC 40PP-S1</li> </ul> |   |
| <b>dB-Lab (&gt;206.318)</b>               | Project Management Software of the KLIPPEL R&D SYSTEM  |   |
| <b>Amplifier</b>                          | A power amplifier is required for performing the measurement.  |   |
| <b>Computer</b>                           | A personal computer is required for performing the measurement.  |   |

### 3 Excitation Signal (Stimulus)

#### Stimulus

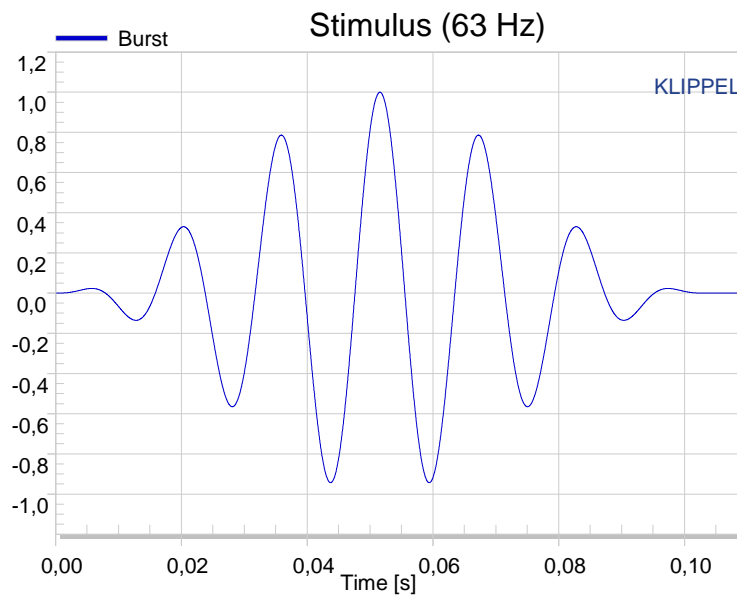
A 1/3 octave band-limited tone-burst signal centered to  $f_0$  is used:

$$f(t) = \begin{cases} \left(1 - \cos \frac{2\pi f_0 t}{6.5}\right) \frac{\sin 2\pi f_0 t}{2} & \text{for } 0 \leq t \leq \frac{6.5}{f_0} \\ 0 & \text{otherwise} \end{cases}$$

$t$  = time [sec]

$f_0$  = center frequency of the burst [Hz]

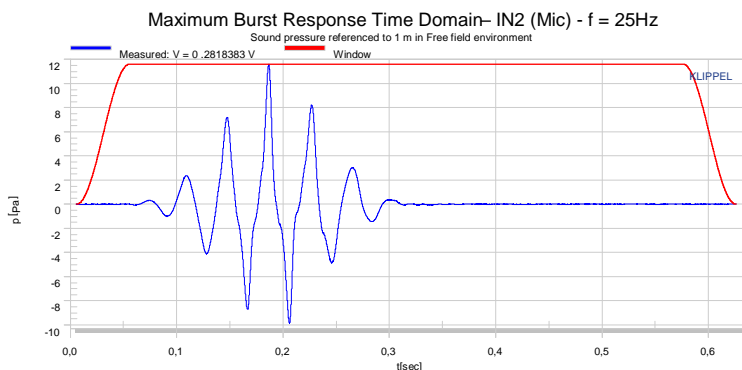
The following picture shows a normalized example test signal burst for  $f_0 = 63\text{Hz}$ .



## 4 Post-processing

### Windowing

The signal measured will be windowed to remove noise and unwanted room reflections. A window rise and decay time of 50ms is used. As defined in the standard CEA2010-B, the window-length is twice the length of the test signal itself.



### Band-pass filtering and peak SPL

The definition of the peak SPL measure by ANSI/CEA-2010-B standard remains with some ambiguity. This Measurement module is kept as flexible and transparent as possible, to allow reproducible burst measurements.

The CEA2010-B standard states:

*The peak SPL of the fundamental shall then be recorded. That is, the peak SPL is the highest peak sound pressure within 1/3 octave of the tone-burst stimulus fundamental frequency range*

This statement is interpreted with the following filtering and peak SPL calculation:

| Band-pass Filtering  |                         | Default Value            |
|--|-------------------------|--------------------------|
| $h_{BP}(t)$ ... Butterworth zero phase 4th order Bandpass<br>$p(t)$ ... Sound pressure signal vs. time<br>$p_{BP}(t) = p(t) * h_{BP}(t)$ |                         |                          |
| Filter type  | Butterworth, zero phase |                          |
| Filter order   | <defined by user input> | 16 <sup>th</sup> order   |
| Filter bandwidth   | <defined by user input> | 6/5 <sup>th</sup> octave |

| Peak SPL  |
|---|
| $SPL_{peak} = 20 * \log \left( \frac{\max( p_{BP}(t) )}{p_{ref}} \right)$ |
| $p_{ref} = 20\mu Pa$  |

The default values of the Band pass filtering are selected to be compliant with the implementation of other measurement systems supporting the standard. However, if it is required, the values can be adjusted for custom needs.

The following picture shows the wave shape of the filter and the signal before and after the filtering process.

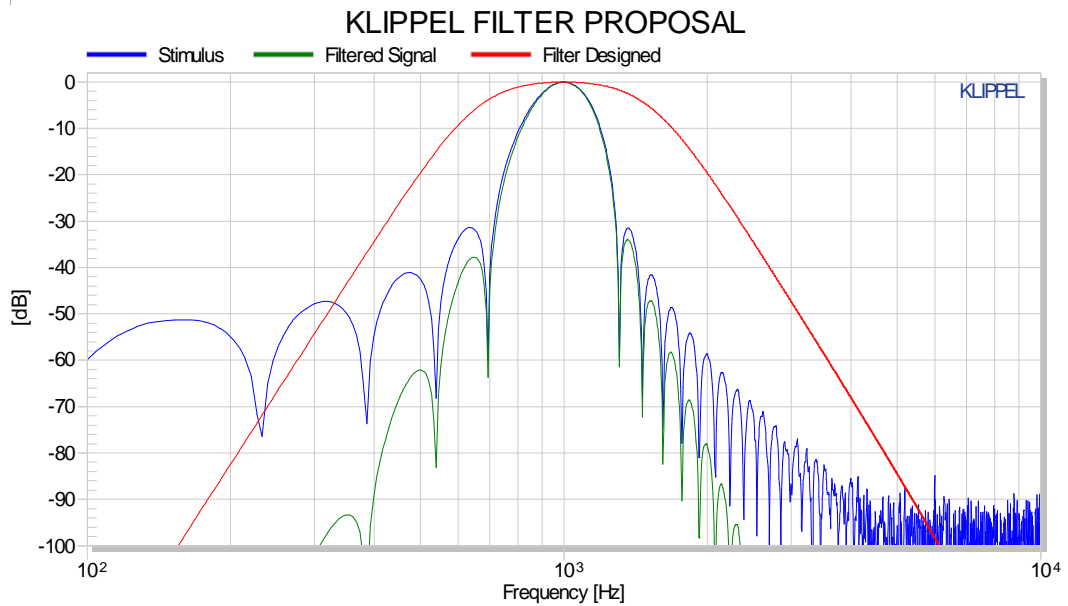


Figure 1: Frequency domain results: red curve is steady state behaviour of Klippel proposed filter, blue curve is burst centred at 1 kHz before filtering process and green curve is the filtered burst

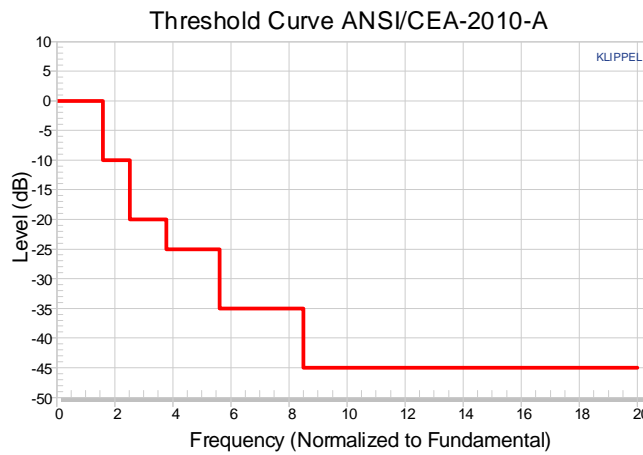
**Smoothing**

The windowed signal is smoothed, in order to eliminate noise and to improve the waveform of the signals in frequency domain. A smoothing factor of 1/12 octave is used as default value according to ANSI/CEA2010-A/B standard. The value may be adjusted if necessary.

**Threshold curve**

Threshold curves, as defined in ANSI/CEA2010-A/B, may be applied to the frequency response of the measured signal. These thresholds define the termination criterion of the measurements at each frequency. User defined thresholds may also be used.

The following picture shows the threshold curve defined by ANSI/CEA-2010-A standard.



## 5 Inputs

### Measurement Setup - Routing

|                                      |  |
|--------------------------------------|--|
| <b>Output at:</b>                    | Point where the voltage defined will be applied to the system. Possible values:<br><ul style="list-style-type: none"> <li>- OUT1</li> <li>- Speaker 1 terminals (via OUT1)</li> <li>- Speaker 2 terminals (via OUT1)</li> <li>- OUT2</li> <li>- Speaker 1 terminals (via OUT2)</li> <li>- Speaker 2 terminals (via OUT2)</li> </ul> <i>Default: Speaker 1 terminals (via OUT1)</i> |
| <b>Input Signal Y1*</b>              | State signal which will be analyzed, and whose results will be compared with threshold. Possible values:<br><ul style="list-style-type: none"> <li>- IN1 (Mic)</li> <li>- IN2 (Mic)</li> </ul> <i>Default: IN1 (Mic)</i>   |
| <b>Input Signal Y2*</b>              | State signal which will be measured simultaneously with state signal 1. Possible values:<br><ul style="list-style-type: none"> <li>- Off</li> <li>- IN1 (Mic)</li> <li>- IN2 (Mic)</li> <li>- Voltage Speaker 1</li> <li>- Voltage Speaker 2</li> <li>- Current Speaker 1</li> <li>- Current Speaker 2</li> <li>- Displacement</li> </ul> <i>Default: off</i>                      |
| <b>Apply Room Correction Curve</b>   | For measurements in non-anechoic environment or small anechoic chambers a correction curve should be used to compensate the room influence. The flag activates the compensation.   |
| <b>Measurement Setup – IN1 (Mic)</b> |  |
| <b>IN1 Meas. Distance [m]</b>        | Measurement distance between microphone and DUT in meter.<br>Min. Value: > 0m      Max. Value: not defined<br><i>Default: 1m</i>   |
| <b>IN1 Environment</b>               | Measurement environment of microphone. Possible values:<br><ul style="list-style-type: none"> <li>- Full space (4 pi)</li> <li>- Half space (2 pi)</li> <li>- <i>Default: Full space (4 pi)</i></li> </ul>   |
| <b>IN1 Calibration [V / dB]</b>      | microphone sensitivity<br>Min. Value: > 0mV      Max. Value: not defined<br><i>Default: 50mV = 93.8 dB SPL</i>   |
| <b>IN1 (Mic) Correction Curve</b>    | Correction filter to compensate the room influence for In-Situ measurements.   |
| <b>Measurement Setup – IN2 (Mic)</b> |  |
| <b>IN2 Meas. Distance [m]</b>        | Measurement distance between microphone and DUT in meter.<br>Min. Value: > 0m      Max. Value: not defined<br><i>Default: 1m</i>   |
| <b>IN2 Environment</b>               | Measurement environment of microphone. Possible values:<br><ul style="list-style-type: none"> <li>- Full space (4 pi)</li> <li>- Half space (2 pi)</li> <li>- <i>Default: Full space (4 pi)</i></li> </ul>   |
| <b>IN2 Calibration [V / dB]</b>      | microphone sensitivity<br>Min. Value: > 0mV      Max. Value: not defined<br><i>Default: 50mV = 93.8 dB SPL</i>   |

|   |   |
|---|---|
| <b>IN2 (Mic) Correction Curve</b>                                     | Correction filter to compensate the room influence for In-Situ measurements.  |
| <b>Stimulus</b>   |   |
| <b>Max. Voltage</b>   | Highest voltage allowed in V. If the threshold is reached before, this voltage will not be measured. To run the operation this value must be defined.<br>Min. Value: Start Voltage Max. Value: 10 if Output at is OUT1 or OUT2<br><i>Default: 0.1</i>   |
| <b>Neglect threshold below [Vp]</b>                                   | Voltage the measurement is continued up to, even if a measurement is failed.<br>Min. Value: not defined Max. Value: Max. Voltage<br><i>Default: 0.02</i>  |
| <b>Start Voltage [Vp]</b>   | Lowest voltage at the input of DUT in V. The measurement starts in this value. To run the operation this value must be defined.<br>Min. Value: 0 Max. Value: not defined<br><i>Default: 0.01</i>  |
| <b>Voltage Step Size [dB]</b><br><i>(ANSI/CEA-2010 Configuration)</i> | Step size of the voltage increment in dB<br>Min. Value: > 0 Max. Value: not defined<br><i>Default: 1</i>  |
| <b>Fundamental Freq. [Hz]</b><br><i>(ANSI/CEA-2010 Configuration)</i> | Vector of frequencies to be analysed in Hz. This Input can be overwritten through Calculate Fundamental Freq. parameter.<br>Min. Value: 10 Max. Value: Sample Rate/6<br><i>Default: [20, 25, 32, 40, 50, 63, 80, 100, 125, 160] (ANSI/CEA-2010-B)</i>   |
| <b>Burst periods</b><br><i>(ANSI/CEA-2010 Configuration)</i>          | Periods of fundamental tone in burst (stimulus signal).<br>Min. Value: 1.5 Max. Value: not defined<br><i>Default: 6.5</i>   |
| <b>Preloop [#]</b><br><i>(ANSI/CEA-2010 Configuration)</i>            | Amount of signal loops to be run before the measurement is recorded<br>Min. Value: 0 Max. Value: 128<br><i>Default: 0</i>   |
| <b>Averaging [#]</b><br><i>(ANSI/CEA-2010 Configuration)</i>          | Number of measurements to average results. Possible values:<br>- 1 - 2<br>- 4 - 8<br>- 16 - 32<br>- 64<br><i>Default: 1</i>   |
| <b>Pause</b>  | Between the measurements, the process can be paused using this parameter.   |
| <b>Processing</b>   |   |
| <b>Smoothing bandwidth</b><br><i>(ANSI/CEA-2010 Configuration)</i>    | Smoothing Bandwidth for results in frequency domain.<br>Min. Value: 1 Max. Value: 99<br><i>Default: 12 (1/12 octave)</i>  |
| <b>Threshold curves</b><br><i>(ANSI/CEA-2010 Configuration)</i>       | Threshold to be compared with the frequency response of the measurements. It is defined by several fields:<br>- <i>freqLimits</i> : 2x1 vector which defines frequency range where threshold is applied: [f <sub>LOW</sub> f <sub>HIGH</sub> ]<br>- <i>freq1 – freq5</i> : Define ranges of fundamental frequencies to applied thres1 – thres5. They are defined as a 2x1 vector: [f <sub>LOW</sub> f <sub>HIGH</sub> ] where f <sub>LOW</sub> ≤ f <sub>RANGE</sub> < f <sub>HIGH</sub> . |

|   |   |
|---|---|
|   | <ul style="list-style-type: none"> <li>- <i>thres1 – thres5</i>: Relative frequencies and amplitudes of the threshold curve saved in a matrix [3xN] First and second columns are minimum and maximum relative freq to apply threshold step. Third column is value of threshold in dB referenced to the peak value of the fundamental frequency.</li> </ul> <p><i>Default: ANSI/CEA-2010-B threshold curve</i></p> |
| <b>Window length [ms]</b><br><i>(ANSI/CEA-2010 Configuration)</i>         | Duration of increment and decrement of Hanning window in milliseconds.<br>Min. Vaue: 0    Max. Value: 500<br><i>Default: 50</i>   |
| <b>Display</b>  |   |
| <b>Update Result Windows</b>  | To monitor the measurement process the result windows can be updated. The Parameter defines how often the windows are recalculated. The curves can be updated after each burst, only after failed measurements or once at the end.  |
| <b>Confirm Measurements</b>   | To get more process control over burst measurement the parameter confirm measurements can activate more user interaction. If it desired the TBM module will ask after every measurement or after all failed measurement how to continue. Thus the user has full control to continue with the next burst or repeat the last measurement.   |
| <b>Frequency [Hz]</b>   | Center frequency of shown results.<br><i>Default: first measurement frequency</i>   |
| <b>Voltage [V]</b>  | Voltage value of measurement to be plotted in windows <i>Spectrum</i> and <i>Time Signal</i> . If it disabled, default value is plotted. Possible values: <ul style="list-style-type: none"> <li>- Max Voltage</li> <li>- Voltages measured at <i>Frequency</i></li> </ul> <i>Default: Max Voltage</i>  |
| <b>Peak Value</b>   | Visualization of plots <i>Y1 Peak Value (u, f)</i> and <i>Y2 Peak Value (u, f)</i> . <ul style="list-style-type: none"> <li>- dB SPL vs Freq</li> <li>- dB SPL vs Voltage</li> </ul> <i>Default: dB SPL vs Voltage</i>  |
| <b>Distortion</b>   | Data domain used in charts <i>Total Burst Distortion</i> , <i>2nd Order Burst Distortion</i> and <i>3rd Order Burst Distortion</i> of signals Y1 and Y2. Possible values: <ul style="list-style-type: none"> <li>- Percentage</li> <li>- dB</li> </ul> <i>Default: Percentage</i>   |
| <b>Results reference distance</b><br><i>(ANSI/CEA-2010 Configuration)</i> | Reference distance between microphone and DUT, in which the results are shown<br>Min. Value: > 0m    Max. Value: not defined<br><i>Default: 1m</i>  |
| <b>Results Environment</b><br><i>(ANSI/CEA-2010 Configuration)</i>        | Results referenced environment, in which the results are shown. Possible values: <ul style="list-style-type: none"> <li>- Full space (4 pi)</li> <li>- Half space (2 pi)</li> </ul> <i>Default: Full space (4 pi)</i>   |

\*NOTE: available selection of state signal Y2 depends on the selection of state signal Y1:

Y1 = In1 -> Y2 may be: In2, Current, Displacement

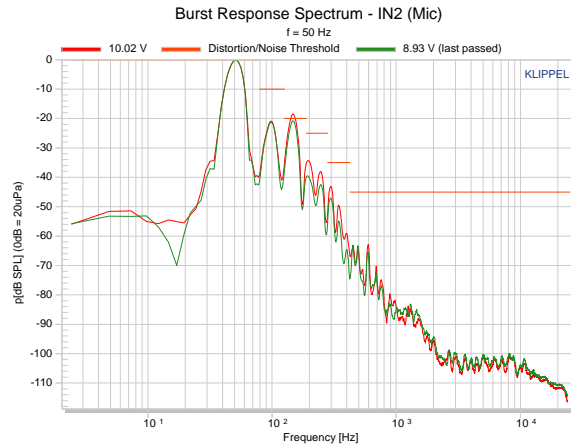
Y1 = In2 -> Y2 may be: In1, Voltage



## 6 Result Windows

### Y1(f) Spectrum

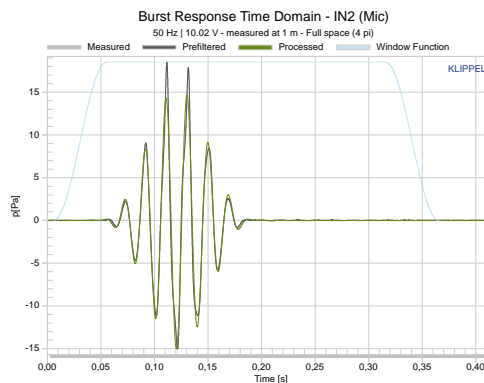
Graph showing the last passed and the first failed measurement of input signal Y1 in frequency domain with the defined threshold curve at the selected frequency. If Voltage parameter is activated, measurement at selected voltage is shown



### Y1(t) Time Signal

Graph showing the recorded input signal Y1 in time domain, and the gated and filtered signal of the last passed measurement of input signal Y1 at the selected frequency. If Voltage parameter is activated, measurement at selected voltage is shown

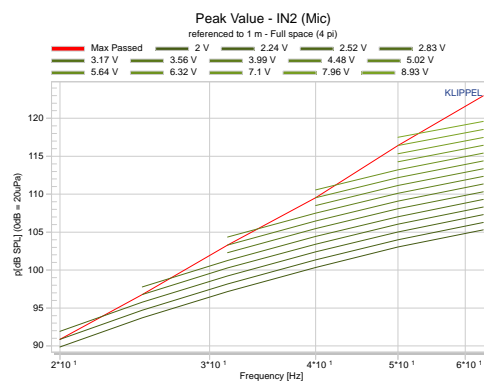
From last passed measurement signal Y1\_peak is determined.

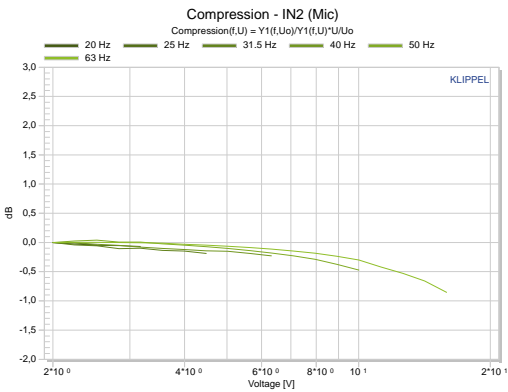
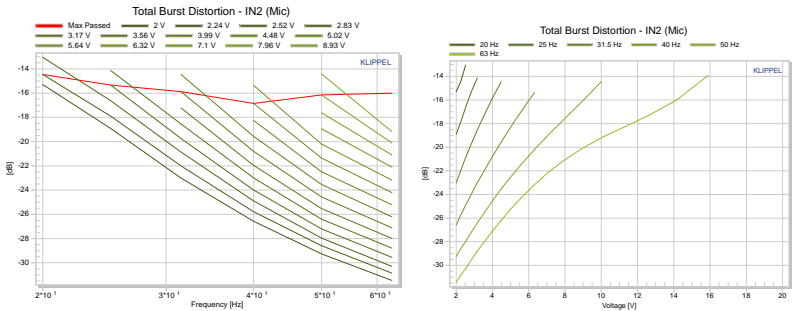


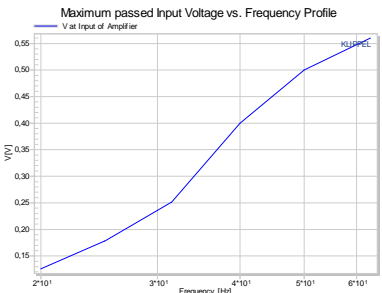
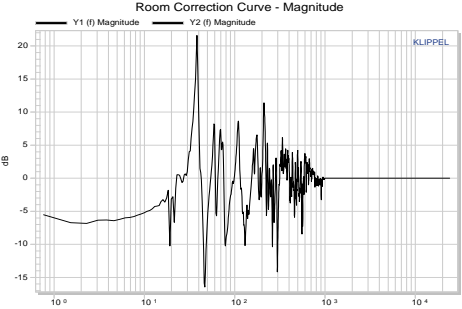
### Y1/Y2 Peak Value

$Y_{PEAK}$ : Peak value of input signal 1 versus voltage and frequency, in dB.

$Y_{PEAK,MAX}(f)$ : Profile of maximal peak SPL value of input signal 1 in frequency domain.



|  |   |
|--|---|
| <p><b>Y1/Y2 Compression</b></p>                | <p>Compression calculated in each signal 1 measurement related to the lowest passed voltage measurement of each frequency.</p>  |
| <p><b>Y1/Y2 Total Burst Dis-tortion</b></p>    | <p>Total burst distortion of all input signal 1 measurements referenced to fundamental burst signal</p>                        |
| <p><b>Y1/Y2 2nd Order Burst Distortion</b></p> | <p>2<sup>nd</sup> order burst distortion of all input signal 1 measurements referenced to fundamental burst signal</p>  |
| <p><b>Y1/Y2 3rd Order Burst Distortion</b></p> | <p>3<sup>rd</sup> order burst distortion of all input signal 1 measurements referenced to fundamental burst signal</p>  |

| <p><b>Max Input Voltage</b></p>        | <p>Graph with the Voltage profile of passed max SPL measurements in frequency domain.</p>   |                                  |  |                       |    |        |        |    |        |      |        |    |        |        |    |        |    |        |              |                      |             |                      |             |     |                   |         |           |       |      |             |              |      |       |                            |          |   |   |                                 |         |   |   |                             |                 |     |   |                                 |       |       |    |             |                 |   |   |                           |                     |     |      |  |           |      |      |                                    |             |      |   |                      |
|--|---|----------------------------------|--|-----------------------|----|--------|--------|----|--------|------|--------|----|--------|--------|----|--------|----|--------|--------------|----------------------|-------------|----------------------|-------------|-----|-------------------|---------|-----------|-------|------|-------------|--------------|------|-------|----------------------------|----------|---|---|---------------------------------|---------|---|---|-----------------------------|-----------------|-----|---|---------------------------------|-------|-------|----|-------------|-----------------|---|---|---------------------------|---------------------|-----|------|--|-----------|------|------|------------------------------------|-------------|------|---|----------------------|
| <p><b>Room Correction Curve</b></p>    | <p>For measurement in small anechoic chambers or non-anechoic rooms it is required to use correction filter that compensates the room influence. The magnitude of the filter is shown in the window.</p>    |                                  |  |                       |    |        |        |    |        |      |        |    |        |        |    |        |    |        |              |                      |             |                      |             |     |                   |         |           |       |      |             |              |      |       |                            |          |   |   |                                 |         |   |   |                             |                 |     |   |                                 |       |       |    |             |                 |   |   |                           |                     |     |      |  |           |      |      |                                    |             |      |   |                      |
| <p><b>Table Results + Settings</b></p> | <p>Shows warnings and errors produced during the process, data collection table of results, measurement conditions and settings of measurement.</p> <p><b>Data Collection Table</b></p> <table border="1"> <thead> <tr> <th>Tone Burst Center Frequency (Hz)</th> <th>Maximum SPL</th> <th>ANSI/CEA2010-A Rating</th> </tr> </thead> <tbody> <tr> <td>20</td> <td>103.88</td> <td rowspan="3">110.65</td> </tr> <tr> <td>25</td> <td>109.54</td> </tr> <tr> <td>31.5</td> <td>115.05</td> </tr> <tr> <td>40</td> <td>121.58</td> <td rowspan="3">125.41</td> </tr> <tr> <td>50</td> <td>125.41</td> </tr> <tr> <td>63</td> <td>128.06</td> </tr> </tbody> </table> <p>Sound pressure referenced to 1 m in Half space (2 pi) environment</p> <p><b>Measurements conditions:</b></p> <table border="1"> <thead> <tr> <th>State Signal</th> <th>Measurement Distance</th> <th>Environment</th> <th><math>L_{MEAS} - L_{REF}</math></th> </tr> </thead> <tbody> <tr> <td>IN2 (Mic 2)</td> <td>1 m</td> <td>Full space (4 pi)</td> <td>6.02 dB</td> </tr> </tbody> </table> <p><b>Settings and Signal 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>S_{MIC\ 2}</math></td> <td>33.6</td> <td>mV/Pa</td> <td>Sensitivity Microphone IN2</td> </tr> <tr> <td>Preloops</td> <td>0</td> <td>-</td> <td>Signal loops before measurement</td> </tr> <tr> <td>Average</td> <td>1</td> <td>-</td> <td>Loops measured and averaged</td> </tr> <tr> <td>Periods of tone</td> <td>6.5</td> <td>-</td> <td>Periods of tone in burst signal</td> </tr> <tr> <td><math>f_s</math></td> <td>48000</td> <td>Hz</td> <td>Sample Rate</td> </tr> <tr> <td>Order of Filter</td> <td>4</td> <td>-</td> <td>Order of band-pass filter</td> </tr> <tr> <td>Bandwidth of Filter</td> <td>1/3</td> <td>oct.</td> <td>Bandwidth of band-pass filter related to central frequency</td> </tr> <tr> <td>Smoothing</td> <td>1/12</td> <td>oct.</td> <td>Frequency response smoothing value</td> </tr> <tr> <td><math>T_{Burst}</math></td> <td>.325</td> <td>s</td> <td>Length of tone burst</td> </tr> </tbody> </table> | Tone Burst Center Frequency (Hz) | Maximum SPL  | ANSI/CEA2010-A Rating | 20 | 103.88 | 110.65 | 25 | 109.54 | 31.5 | 115.05 | 40 | 121.58 | 125.41 | 50 | 125.41 | 63 | 128.06 | State Signal | Measurement Distance | Environment | $L_{MEAS} - L_{REF}$ | IN2 (Mic 2) | 1 m | Full space (4 pi) | 6.02 dB | Parameter | Value | Unit | Description | $S_{MIC\ 2}$ | 33.6 | mV/Pa | Sensitivity Microphone IN2 | Preloops | 0 | - | Signal loops before measurement | Average | 1 | - | Loops measured and averaged | Periods of tone | 6.5 | - | Periods of tone in burst signal | $f_s$ | 48000 | Hz | Sample Rate | Order of Filter | 4 | - | Order of band-pass filter | Bandwidth of Filter | 1/3 | oct. | Bandwidth of band-pass filter related to central frequency | Smoothing | 1/12 | oct. | Frequency response smoothing value | $T_{Burst}$ | .325 | s | Length of tone burst |
| Tone Burst Center Frequency (Hz)       | Maximum SPL   | ANSI/CEA2010-A Rating            |  |                       |    |        |        |    |        |      |        |    |        |        |    |        |    |        |              |                      |             |                      |             |     |                   |         |           |       |      |             |              |      |       |                            |          |   |   |                                 |         |   |   |                             |                 |     |   |                                 |       |       |    |             |                 |   |   |                           |                     |     |      |  |           |      |      |                                    |             |      |   |                      |
| 20                                     | 103.88  | 110.65                           |  |                       |    |        |        |    |        |      |        |    |        |        |    |        |    |        |              |                      |             |                      |             |     |                   |         |           |       |      |             |              |      |       |                            |          |   |   |                                 |         |   |   |                             |                 |     |   |                                 |       |       |    |             |                 |   |   |                           |                     |     |      |  |           |      |      |                                    |             |      |   |                      |
| 25                                     | 109.54  |                                  |  |                       |    |        |        |    |        |      |        |    |        |        |    |        |    |        |              |                      |             |                      |             |     |                   |         |           |       |      |             |              |      |       |                            |          |   |   |                                 |         |   |   |                             |                 |     |   |                                 |       |       |    |             |                 |   |   |                           |                     |     |      |  |           |      |      |                                    |             |      |   |                      |
| 31.5                                   | 115.05  |                                  |  |                       |    |        |        |    |        |      |        |    |        |        |    |        |    |        |              |                      |             |                      |             |     |                   |         |           |       |      |             |              |      |       |                            |          |   |   |                                 |         |   |   |                             |                 |     |   |                                 |       |       |    |             |                 |   |   |                           |                     |     |      |  |           |      |      |                                    |             |      |   |                      |
| 40                                     | 121.58  | 125.41                           |  |                       |    |        |        |    |        |      |        |    |        |        |    |        |    |        |              |                      |             |                      |             |     |                   |         |           |       |      |             |              |      |       |                            |          |   |   |                                 |         |   |   |                             |                 |     |   |                                 |       |       |    |             |                 |   |   |                           |                     |     |      |  |           |      |      |                                    |             |      |   |                      |
| 50                                     | 125.41  |                                  |  |                       |    |        |        |    |        |      |        |    |        |        |    |        |    |        |              |                      |             |                      |             |     |                   |         |           |       |      |             |              |      |       |                            |          |   |   |                                 |         |   |   |                             |                 |     |   |                                 |       |       |    |             |                 |   |   |                           |                     |     |      |  |           |      |      |                                    |             |      |   |                      |
| 63                                     | 128.06  |                                  |  |                       |    |        |        |    |        |      |        |    |        |        |    |        |    |        |              |                      |             |                      |             |     |                   |         |           |       |      |             |              |      |       |                            |          |   |   |                                 |         |   |   |                             |                 |     |   |                                 |       |       |    |             |                 |   |   |                           |                     |     |      |  |           |      |      |                                    |             |      |   |                      |
| State Signal                           | Measurement Distance  | Environment                      | $L_{MEAS} - L_{REF}$                                       |                       |    |        |        |    |        |      |        |    |        |        |    |        |    |        |              |                      |             |                      |             |     |                   |         |           |       |      |             |              |      |       |                            |          |   |   |                                 |         |   |   |                             |                 |     |   |                                 |       |       |    |             |                 |   |   |                           |                     |     |      |  |           |      |      |                                    |             |      |   |                      |
| IN2 (Mic 2)                            | 1 m   | Full space (4 pi)                | 6.02 dB  |                       |    |        |        |    |        |      |        |    |        |        |    |        |    |        |              |                      |             |                      |             |     |                   |         |           |       |      |             |              |      |       |                            |          |   |   |                                 |         |   |   |                             |                 |     |   |                                 |       |       |    |             |                 |   |   |                           |                     |     |      |  |           |      |      |                                    |             |      |   |                      |
| Parameter                              | Value   | Unit                             | Description  |                       |    |        |        |    |        |      |        |    |        |        |    |        |    |        |              |                      |             |                      |             |     |                   |         |           |       |      |             |              |      |       |                            |          |   |   |                                 |         |   |   |                             |                 |     |   |                                 |       |       |    |             |                 |   |   |                           |                     |     |      |  |           |      |      |                                    |             |      |   |                      |
| $S_{MIC\ 2}$                           | 33.6  | mV/Pa                            | Sensitivity Microphone IN2                                 |                       |    |        |        |    |        |      |        |    |        |        |    |        |    |        |              |                      |             |                      |             |     |                   |         |           |       |      |             |              |      |       |                            |          |   |   |                                 |         |   |   |                             |                 |     |   |                                 |       |       |    |             |                 |   |   |                           |                     |     |      |  |           |      |      |                                    |             |      |   |                      |
| Preloops                               | 0   | -                                | Signal loops before measurement                            |                       |    |        |        |    |        |      |        |    |        |        |    |        |    |        |              |                      |             |                      |             |     |                   |         |           |       |      |             |              |      |       |                            |          |   |   |                                 |         |   |   |                             |                 |     |   |                                 |       |       |    |             |                 |   |   |                           |                     |     |      |  |           |      |      |                                    |             |      |   |                      |
| Average                                | 1   | -                                | Loops measured and averaged                                |                       |    |        |        |    |        |      |        |    |        |        |    |        |    |        |              |                      |             |                      |             |     |                   |         |           |       |      |             |              |      |       |                            |          |   |   |                                 |         |   |   |                             |                 |     |   |                                 |       |       |    |             |                 |   |   |                           |                     |     |      |  |           |      |      |                                    |             |      |   |                      |
| Periods of tone                        | 6.5   | -                                | Periods of tone in burst signal                            |                       |    |        |        |    |        |      |        |    |        |        |    |        |    |        |              |                      |             |                      |             |     |                   |         |           |       |      |             |              |      |       |                            |          |   |   |                                 |         |   |   |                             |                 |     |   |                                 |       |       |    |             |                 |   |   |                           |                     |     |      |  |           |      |      |                                    |             |      |   |                      |
| $f_s$                                  | 48000   | Hz                               | Sample Rate  |                       |    |        |        |    |        |      |        |    |        |        |    |        |    |        |              |                      |             |                      |             |     |                   |         |           |       |      |             |              |      |       |                            |          |   |   |                                 |         |   |   |                             |                 |     |   |                                 |       |       |    |             |                 |   |   |                           |                     |     |      |  |           |      |      |                                    |             |      |   |                      |
| Order of Filter                        | 4   | -                                | Order of band-pass filter                                  |                       |    |        |        |    |        |      |        |    |        |        |    |        |    |        |              |                      |             |                      |             |     |                   |         |           |       |      |             |              |      |       |                            |          |   |   |                                 |         |   |   |                             |                 |     |   |                                 |       |       |    |             |                 |   |   |                           |                     |     |      |  |           |      |      |                                    |             |      |   |                      |
| Bandwidth of Filter                    | 1/3   | oct.                             | Bandwidth of band-pass filter related to central frequency |                       |    |        |        |    |        |      |        |    |        |        |    |        |    |        |              |                      |             |                      |             |     |                   |         |           |       |      |             |              |      |       |                            |          |   |   |                                 |         |   |   |                             |                 |     |   |                                 |       |       |    |             |                 |   |   |                           |                     |     |      |  |           |      |      |                                    |             |      |   |                      |
| Smoothing                              | 1/12  | oct.                             | Frequency response smoothing value                         |                       |    |        |        |    |        |      |        |    |        |        |    |        |    |        |              |                      |             |                      |             |     |                   |         |           |       |      |             |              |      |       |                            |          |   |   |                                 |         |   |   |                             |                 |     |   |                                 |       |       |    |             |                 |   |   |                           |                     |     |      |  |           |      |      |                                    |             |      |   |                      |
| $T_{Burst}$                            | .325  | s                                | Length of tone burst                                       |                       |    |        |        |    |        |      |        |    |        |        |    |        |    |        |              |                      |             |                      |             |     |                   |         |           |       |      |             |              |      |       |                            |          |   |   |                                 |         |   |   |                             |                 |     |   |                                 |       |       |    |             |                 |   |   |                           |                     |     |      |  |           |      |      |                                    |             |      |   |                      |
| <p><b>Table Peak SPL</b></p>           | <p>Shows a summary with the entire peak SPL values obtained in each measurement.</p>  |                                  |  |                       |    |        |        |    |        |      |        |    |        |        |    |        |    |        |              |                      |             |                      |             |     |                   |         |           |       |      |             |              |      |       |                            |          |   |   |                                 |         |   |   |                             |                 |     |   |                                 |       |       |    |             |                 |   |   |                           |                     |     |      |  |           |      |      |                                    |             |      |   |                      |

| Peak Values - IN2 (Mic)               |          |          |           |           |           |           |
|---------------------------------------|----------|----------|-----------|-----------|-----------|-----------|
| referenced to 1 m - Full space (4 pi) |          |          |           |           |           |           |
|                                       | 20 Hz    | 25 Hz    | 31.5 Hz   | 40 Hz     | 50 Hz     | 63 Hz     |
| 20 V                                  | -        | -        | -         | -         | -         | -         |
| 17.83 V                               | -        | -        | -         | -         | -         | -         |
| 15.89 V                               | -        | -        | -         | -         | -         | 124.16 dB |
| 14.16 V                               | -        | -        | -         | -         | -         | 122.96 dB |
| 12.62 V                               | -        | -        | -         | -         | -         | 121.83 dB |
| 11.25 V                               | -        | -        | -         | -         | -         | 120.72 dB |
| 10.02 V                               | -        | -        | -         | -         | 117.51 dB | 119.6 dB  |
| 8.93 V                                | -        | -        | -         | -         | 116.42 dB | 118.54 dB |
| 7.96 V                                | -        | -        | -         | -         | 115.33 dB | 117.49 dB |
| 7.1 V                                 | -        | -        | -         | -         | 114.28 dB | 116.45 dB |
| 6.32 V                                | -        | -        | -         | 110.57 dB | 113.22 dB | 115.41 dB |
| 5.64 V                                | -        | -        | -         | 109.54 dB | 112.19 dB | 114.4 dB  |
| 5.02 V                                | -        | -        | -         | 108.49 dB | 111.14 dB | 113.36 dB |
| 4.48 V                                | -        | -        | 104.34 dB | 107.5 dB  | 110.12 dB | 112.35 dB |
| 3.99 V                                | -        | -        | 103.3 dB  | 106.47 dB | 109.09 dB | 111.33 dB |
| 3.56 V                                | -        | -        | 102.29 dB | 105.46 dB | 108.07 dB | 110.32 dB |
| 3.17 V                                | -        | 97.78 dB | 101.25 dB | 104.43 dB | 107.04 dB | 109.31 dB |
| 2.83 V                                | -        | 96.78 dB | 100.27 dB | 103.42 dB | 106.05 dB | 108.32 dB |
| 2.52 V                                | 91.92 dB | 95.77 dB | 99.22 dB  | 102.39 dB | 105.01 dB | 107.31 dB |
| 2.24 V                                | 90.88 dB | 94.7 dB  | 98.18 dB  | 101.34 dB | 104 dB    | 106.28 dB |
| 2 V                                   | 89.87 dB | 93.72 dB | 97.15 dB  | 100.35 dB | 103.04 dB | 105.3 dB  |

**Measurement Monitor**

The measurement Monitor gives basic information about the last burst measurement. It shows the frequency, the voltage and the result of the threshold check. In following example the 3<sup>rd</sup> order distortion exceeds the limit so the frequency band of from 126 Hz – 189 Hz failed.

| Frequency | 50 Hz   |
|-----------|---------|
| Voltage   | 10.02 V |

**FAIL**

| Frequency       | Threshold | Verdict |
|-----------------|-----------|---------|
| 0 Hz - 80 Hz    | 0 dB      | PASS    |
| 80 Hz - 126 Hz  | -10 dB    | PASS    |
| 126 Hz - 189 Hz | -20 dB    | FAIL    |
| 189 Hz - 281 Hz | -25 dB    | PASS    |
| 281 Hz - 425 Hz | -35 dB    | PASS    |
| 425 Hz - 25 kHz | -45 dB    | PASS    |

Find explanations for symbols at:

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

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