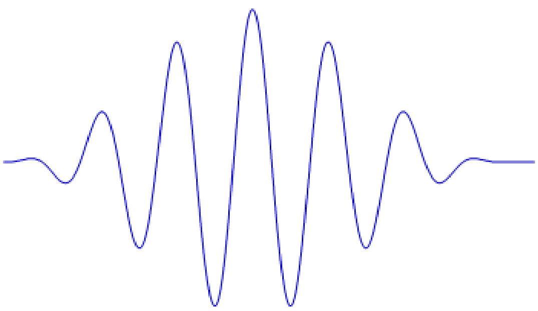
TBM - Tone Burst Measurement S44

Software of the KLIPPEL R&D and QC SYSTEM (Document Revision 1.10)

FEATURES

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



DESCRIPTION

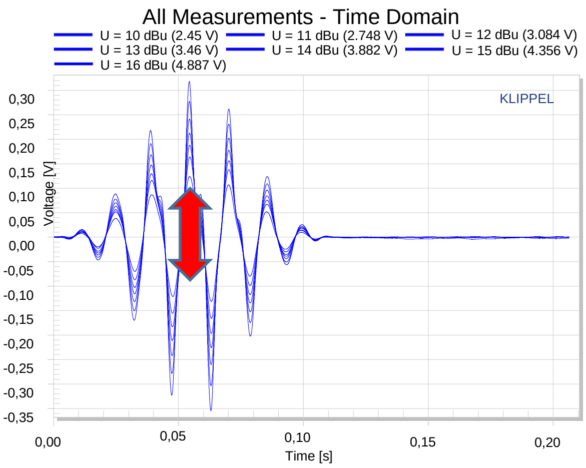
The TBM Module uses a transient sinusoidal burst to measure the peak SPL and harmonic distortion versus frequency and amplitude according to Standard ANSI/CEA-2010 and ANSI/CEA-2034. If the distortion exceeds a user defined threshold, the input amplitude will be not increased to prevent a damage of the 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.

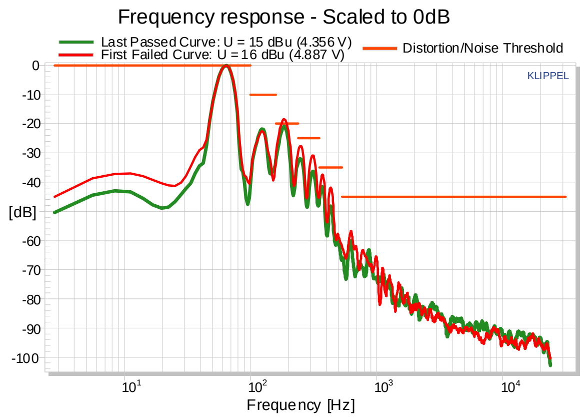
Article number	1001-109

CONTENT

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 1/12th 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 Excitation Signal (Stimulus)

Stimulus

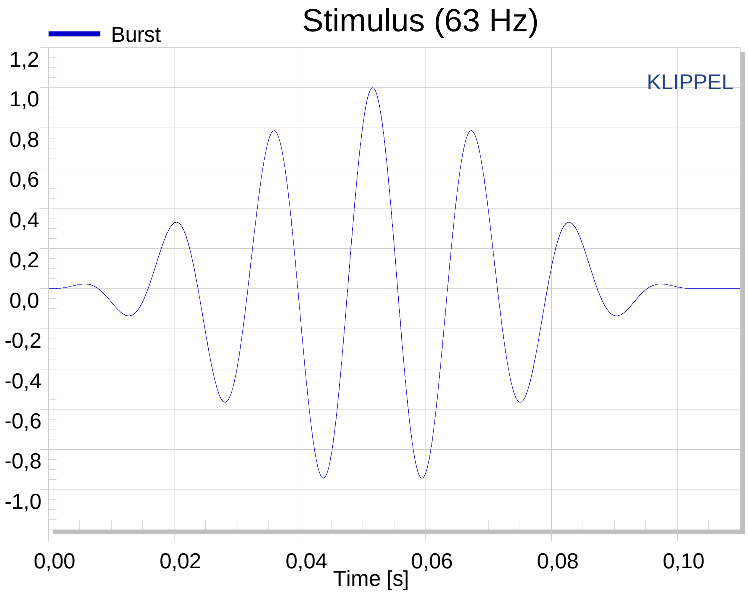
A 1/3 octave band-limited tone-burst signal centered to $f_\circ$ is used:

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

t = time [sec]

$f_\circ$ = center frequeny of the burst [Hz]

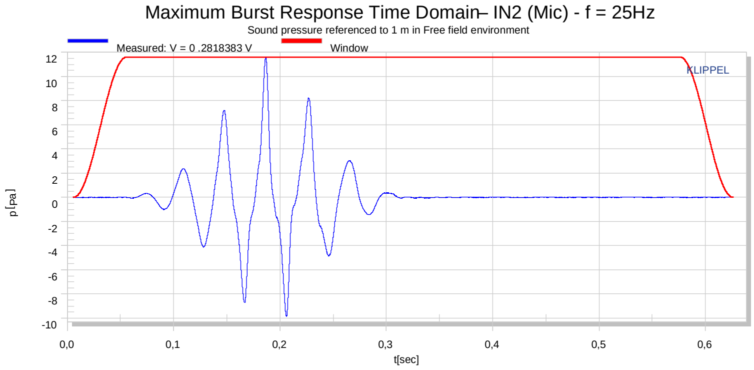
The following picture shows a normalized example test signal burst for $f_\circ = 63Hz$.



3 Post-processing

Windowing

The signal measured will be windowed to remove noise and unwanted room reflections. 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 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

$h_{BP}(t)$ ... *Butterworth zero phase 4th order Bandpass*

$p(t)$ ... *Sound pressure signal vs. time*

$$p_{BP}(t) = p(t) * h_{BP}(t)$$

Filter type	Butterworth, zero phase
Filter order	16^{th} order
Filter bandwidth	$6/5^{th}$ octave

Peak SPL

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

p_{ref} = 20µPa

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

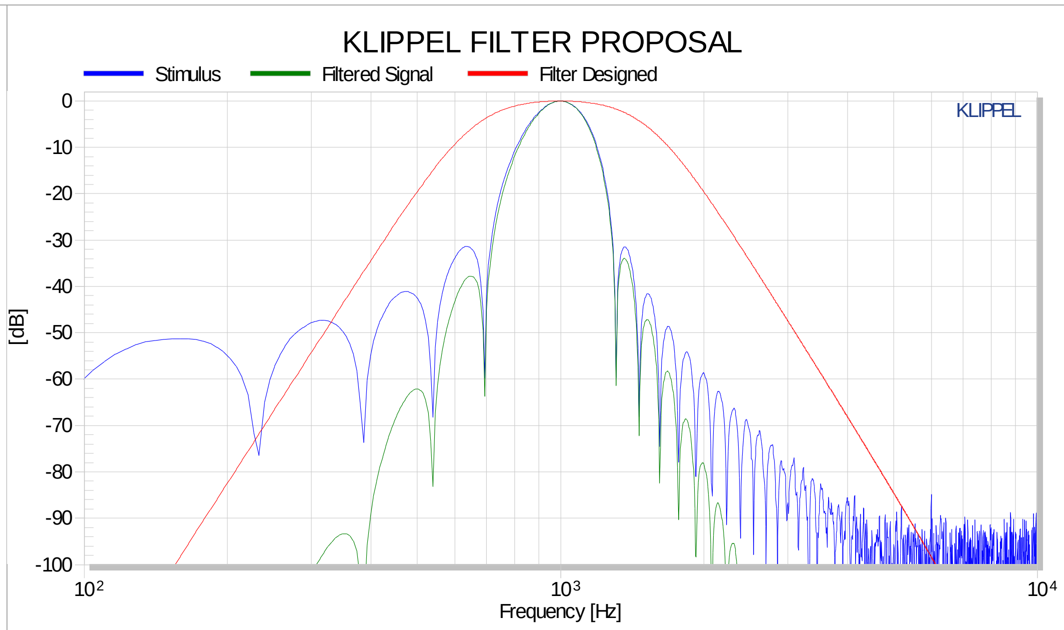


Figure 1: Frequency domain results: red curve is steady state behaviour of Klippel proposed filter, blue curve is burst centred at 1 kHz before filtering process and green curve is the filtered burst

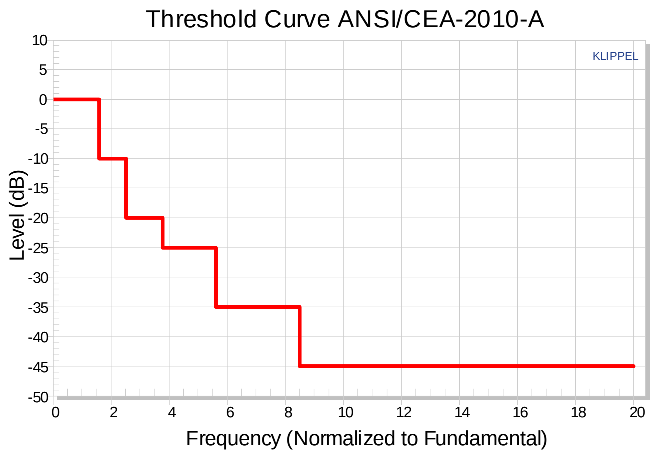
Smoothing

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 and ANSI/CEA2034, 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.



4 Requirements

4.1 Hardware

Analyzer		The Distortion Analyzer or the Klippel Analyzer 3 are used as the hardware to perform the measurement.
Microphone	*[optional]* Free field microphone with omnidirectional directivity characteristic over the desired measurement bandwidth.	
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.	
Computer	A personal computer is required for performing the measurement.	

4.2 Software

dB-Lab	Project Management Software of the KLIPPEL R&D SYSTEM. Requires at least version 210.450.

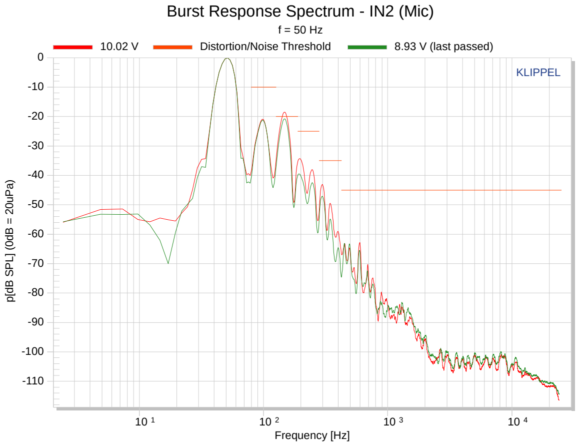
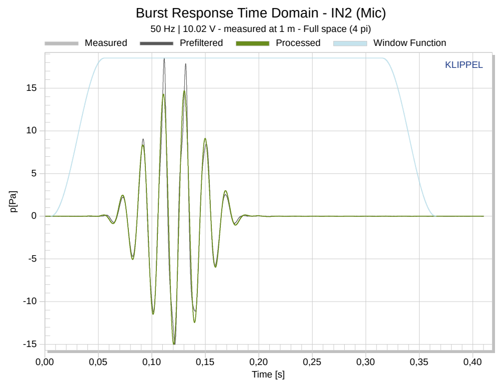
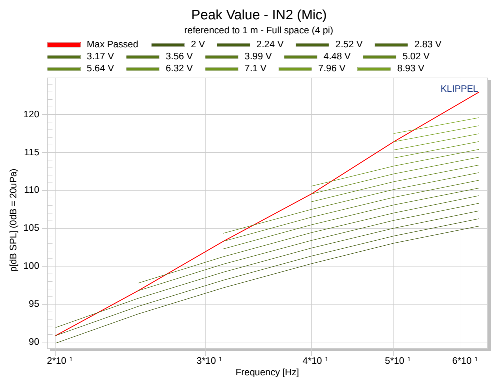
5 Inputs

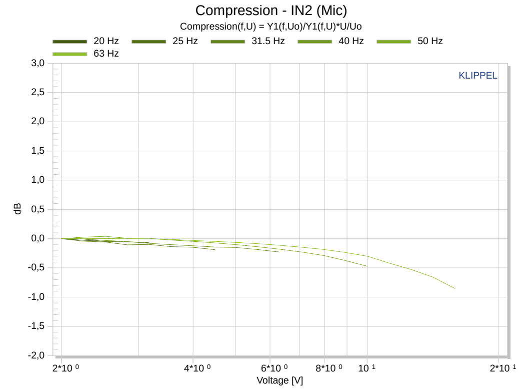
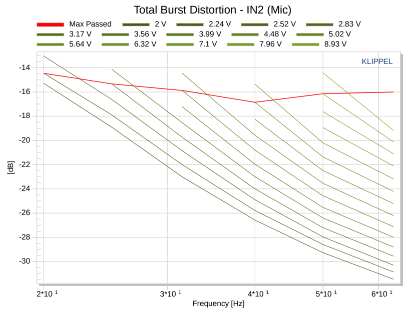
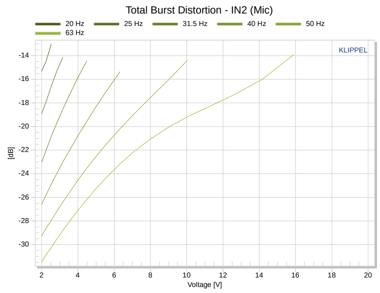
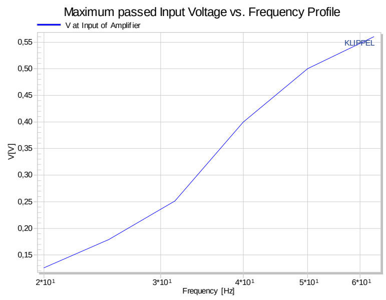
Measurement Setup - Routing	
Output at:	Point where the voltage defined will be applied to the system. Possible values: - OUT1 - Speaker 1 terminals (via OUT1) - Speaker 2 terminals (via OUT1) - OUT2 - Speaker 1 terminals (via OUT2) - Speaker 2 terminals (via OUT2) *Default: Speaker 1 terminals (via OUT1)*
Input Signal Y1	State signal which will be analyzed, und whose results will be compared with threshold. Possible values: - IN1 (Mic) - Voltage Speaker 1 - Current Speaker 1 - Displacement - IN2 (Mic) - Voltage Speaker 2 - Current Speaker 2 *Default: IN1 (Mic)*
Input Signal Y2	State signal which will be measured simultaneously with state signal 1. Possible values: - Off - IN2 (Mic) - Voltage Speaker 2 - Current Speaker 2 - IN1 (Mic) - Voltage Speaker 1 - Current Speaker 1 - Displacement *Default: Off*
Apply Room Correction Curve	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.
Measurement Setup – IN1 (Mic) (same for IN2 (Mic))	
IN1 Meas. Distance [m]	Measurement distance between microphone and DUT in meter. *Default: 1m*
IN1 Environment	Measurement environment of microphone. Possible values: - Full space (4 pi) - Half space (2 pi) *Default: Full space (4 pi)*
IN1 Microphone Sensitivity	Microphone sensitivity defined in mV / Pa *Default: 50mV / Pa*
IN1 (Mic) Room Correction Curve	Correction filter to compensate the room influence for In-Situ measurements.
IN1 (Mic) Microphone Correction Curve	Microphone calibration curve.
Stimulus	
Voltage Range Definition	Measurement voltages can be defined according three different modes: - Fix Step size: voltage raises according a fix step size - Single Voltage: a single voltage is measured per frequency - User Defined: User defines voltages to be measured at each frequency *Default: Fix Step Size*

Max. Voltage	Highest voltage allowed in V. If the threshold is reached before, this voltage will not be measured. This parameter is only available if *Voltage Range Definition* is *Fix Step Size*. *Default: 5V*
Neglect threshold below [Vp]	Voltage the measurement is continued up to, even if a measurement is failed. This parameter is only available if *Voltage Range Definition* is *Fix Step Size*. *Default: 2V*
Start Voltage [Vp]	Lowest voltage at the input of DUT in V. The measurement starts at this value. This parameter is only available if *Voltage Range Definition* is *Fix Step Size*. *Default: 1V*
Voltage Step Size [dB]	Step size of the voltage increment in dB. This parameter is only available if *Voltage Range Definition* is *Fix Step Size*. *Default: 1dB*
Voltage	Single voltage measured per frequency. This parameter is only available if *Voltage Range Definition* is *Single voltage*. *Default: 1V*
Voltage Profile	Voltages to be measured at each frequency. This parameter is only available if *Voltage Range Definition* is *User Defined*.
Fundamental Freq. [Hz]	Vector of frequencies to be analysed in Hz. This Input can be overwritten through Calculate Fundamental Freq. parameter. *Default: [20, 25, 32, 40, 50, 63, 80, 100, 125, 160] (ANSI/CEA-2010-B)*
Burst periods	Periods of fundamental tone in burst (stimulus signal). *Default: 6.5*
Preloop [#]	Amount of signal loops to be run before the measurement is recorded *Default: 0*
Averaging [#]	Number of measurements to average results. Possible values: - 1 - 2 - 4 - 8 - 16 - 32 - 64 *Default: 1*
Pause	Between the measurements, the process can be paused using this parameter.
Processing	
Smoothing bandwidth	Smoothing Bandwidth for results in frequency domain. *Default: 12 (1/12 octave)*
Activate Threshold	This parameter activates the use of the threshold in the measurements.

Threshold curves	Threshold to be compared with the frequency response of the measurements. It is defined by several fields: - *freqLimits*: 2x1 vector which defines frequency range where threshold is applied: [f_{LOW} f_{HIGH}] - *freq1 – freq5*: Define ranges of fundamental frequencies to applied thres1 – thres5. They are defined as a 2x1 vector: [f_{LOW} f_{HIGH}] where $f_{LOW} \leq f_{RANGE} < f_{HIGH}$. - *thres1 – thres5*: 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. *Default: ANSI/CEA-2010-B threshold curve*
Display	
Update Result Windows	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.
Confirm Measurements	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.
Frequency [Hz]	Center frequency of shown results. *Default: first measurement frequency*
Voltage [V]	Voltage value of measurement to be plotted in windows *Spectrum* and *Time Signal*. If it disabled, default value is plotted. Possible values: - Max Voltage - Voltages measured at *Frequency* *Default: Max Voltage*
Peak Value	Visualization of plots *Y1 Peak Value (u, f)* and *Y2 Peak Value (u, f)*. - dB SPL vs Freq - dB SPL vs Voltage *Default: dB SPL vs Voltage*
Distortion	Data domain used in charts *Total Burst Distortion*, *2nd Order Burst Distortion* and *3rd Order Burst Distortion* of signals Y1 and Y2. Possible values: - Percentage - dB *Default: Percentage*
Results reference distance	Reference distance between microphone and DUT, in which the results are shown *Default: 1m*
Results Environment	Results referenced environment, in which the results are shown. Possible values: - Full space (4 pi) - Half space (2 pi) *Default: Full space (4 pi)*

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, gated and filtered signal of the last passed measurement of input signal Y1 in time domain. 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. 

Y1/Y2 Compression	Compression calculated in each signal 1 measurement related to the lowest passed voltage measurement of each frequency. 
Y1/Y2 Total Burst Distortion	Total burst distortion of all input signal 1 measurements referenced to fundamental burst signal.  
Y1/Y2 2nd Order Burst Distortion	2nd order burst distortion of all input signal 1 measurements referenced to fundamental burst signal.
Y1/Y2 3rd Order Burst Distortion	3rd order burst distortion of all input signal 1 measurements referenced to fundamental burst signal.
Max Input Voltage	Graph with the Voltage profile of passed max SPL measurements in frequency domain. 

Correction Curve

For measurements in small anechoic chambers or non-anechoic rooms it is required to use correction filter that compensates the room influence. The magnitude of this room correction filter as well as the microphone correction curve are shown in the window.

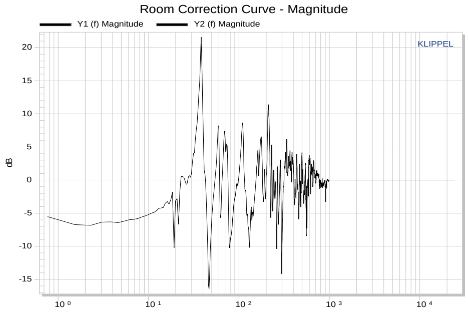


Table Results + Settings

Shows warnings and errors produced during the process, data collection table of results, measurement conditions and settings of measurement.

Data Collection 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	
Sound pressure referenced to 1 m in Half space (2 pi) environment		

Measurements conditions:

State Signal	Measurement Distance	Environment	$L_{MEAS} - L_{REF}$
IN2 (Mic 2)	1 m	Full space (4 pi)	6.02 dB

Settings and Signal properties:

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

Table Peak SPL

Shows a summary with the entire peak SPL values obtained in each measurement.

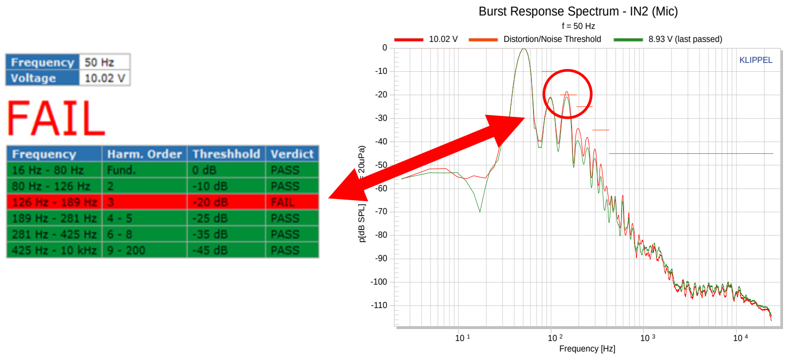
Peak Values - IN2 (Mic)

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 3rd order distortion exceeds the limit so the frequency band of from 126 Hz – 189 Hz failed.



7 References

7.1 Related Modules	Live Audio Analyzer (LAA) Distortion Measurement (DIS) Transfer Function Measurement (TRF) Multi-Tone Measurement (MTON) In-Situ Room Compensation (ISC)
7.2 Manuals	Tone Burst Measurement Manual
7.3 Standards	ANSI/CEA-2010-A: "Standard Method of Measurement for Powered Sub-woofers", 2012, Consumer Electronics Association ANSI/CEA-2010-B: "Standard Method of Measurement for Subwoofers", 2014, Consumer Electronics Association ANSI/CEA-2034: "Standard Method of Measurement for In-Home Loud-speakers", 2013, Consumer Electronics Association

Find explanations for symbols at:

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

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