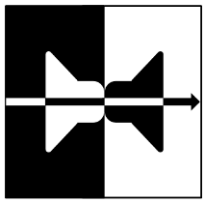
KCS SYSTEM USER'S GUIDE

KCS Evaluation Tutorials



August 16, 2022

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Contents

1 Goal of this Guide

This document describes how to evaluate the KLIPPEL Controlled Sound technology (KCS) by using the KLIPPEL QC measurement framework. The following topics are covered:

- Measuring the frequency response
- Evaluation of the performance of active systems including KCS in the large signal domain
- Evaluation of the KCS speaker protection
- Evaluation of multi-tone distortion compensation
- How to treat Rub&Buzz problems

2 Requirements

Its mandatory to read the document *Manual KCS Monitor.pdf* which teaches necessary KCS basic knowledge before the KCS evaluation tutorials are executed!

Hardware:

- KCS hardware platform *(e.g. Nuvoton Audio Development* Board (NAD), Klippel Analyzer 3 (KA3), APE Evaluation Board etc.)
- Measurement Equipment. There are two options:
    - KA3 measurement device:
        - Klippel Analyzer 3 (KA3)
        - Microphone
    - NAD on-board microphone (*DMIC*):
        - Klippel Dongle
        - DMIC module mounted on NAD board

Software:

- Klippel dB-Lab of version >= 210.826
- Licenses for: QC Standard 6 for KCS, SPL task, Multi-tone distortion task, SYN, 3DL
- Additional License (only for QC measurement with NAD board DMIC): QC no PA hardware required (== QC Standalone)

In addition, following Klippel dB-Lab operations are required:

- KCS Monitor operation comprising initial data for the particular DUT
- QC operation template ***KCS Evaluation Template.kdbx***

3 Hardware Setup

There are different hardware setups dependent on the device on which KCS is running (KCS device) and what device is used as input device for the QC measurement (QC measurement device). Details about specific hardware setups applicable for your particular application are listed in the chapters below.

KCS device	QC measurement device	Related hardware setup chapter
Nuvoton Platform (NAD)	Klippel KA3	3.1 KCS running on Nuvoton Platform (NAD) ⇨ *Hardware Connection using KA3 as QC Input Device*
Nuvoton Platform (NAD)	NAD DMIC (= NAD onboard mic)	3.1 KCS running on Nuvoton Platform (NAD) ⇨ *Hardware Connection using NAD DMIC as QC Input Device*
Klippel KA3 (using internal AmpCard)	Klippel KA3	3.2 KCS running on Klippel Devices ⇨ *Hardware Connection using KA3 with AMP Card*
Klippel KA3 (using an external Amp)	Klippel KA3	3.2 KCS running on Klippel Devices ⇨ *Hardware Connection using KA3 with external Amplifier*
Klippel APE EVB (standalone evaluation board)	Klippel KA3	3.2 KCS running on Klippel Devices ⇨ *Hardware Connection using APE Evaluation Board*

3.1 KCS running on Nuvoton Platform (NAD)

General System Overview

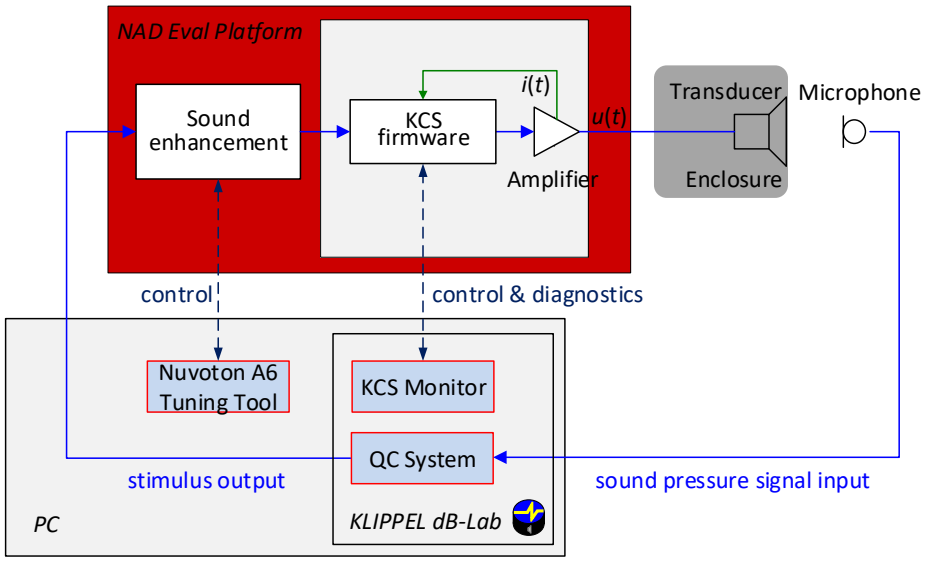


Figure 1: Schematic Diagram of Evaluation Environment using NAD board

Hardware Connection using KA3 as QC Input Device

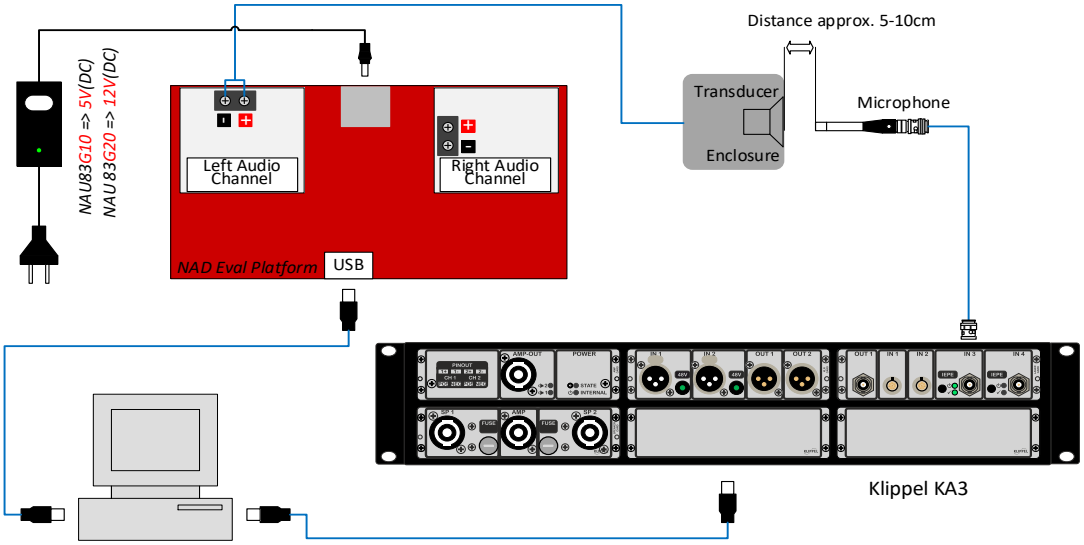


Figure 2:Hardware Connection using NAD board and KA3

Hardware Connection using NAD DMIC as QC Input Device

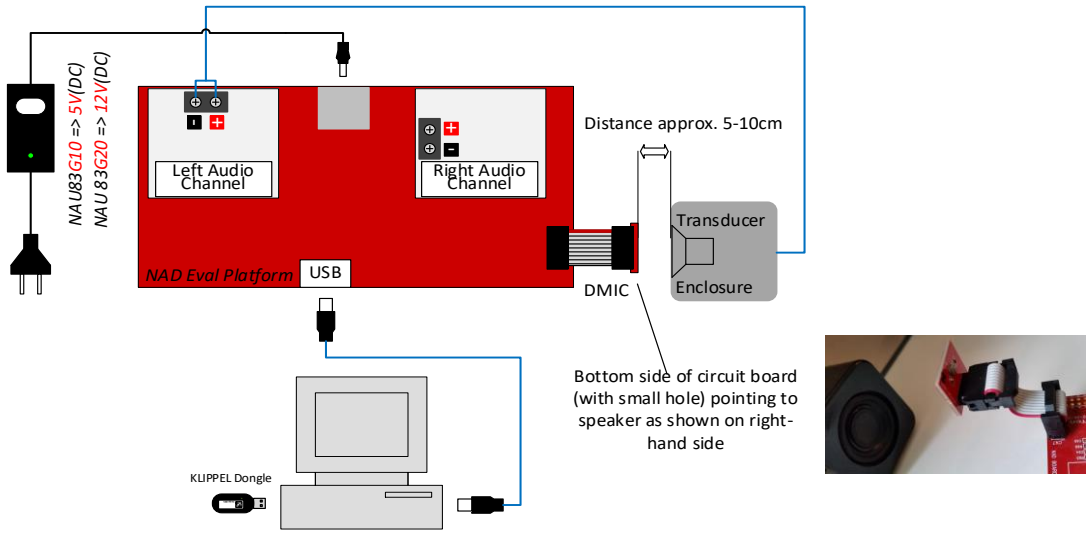


Figure 3:Hardware Connection using NAD board with DMIC

3.2 KCS running on Klippel Devices

General System Overview

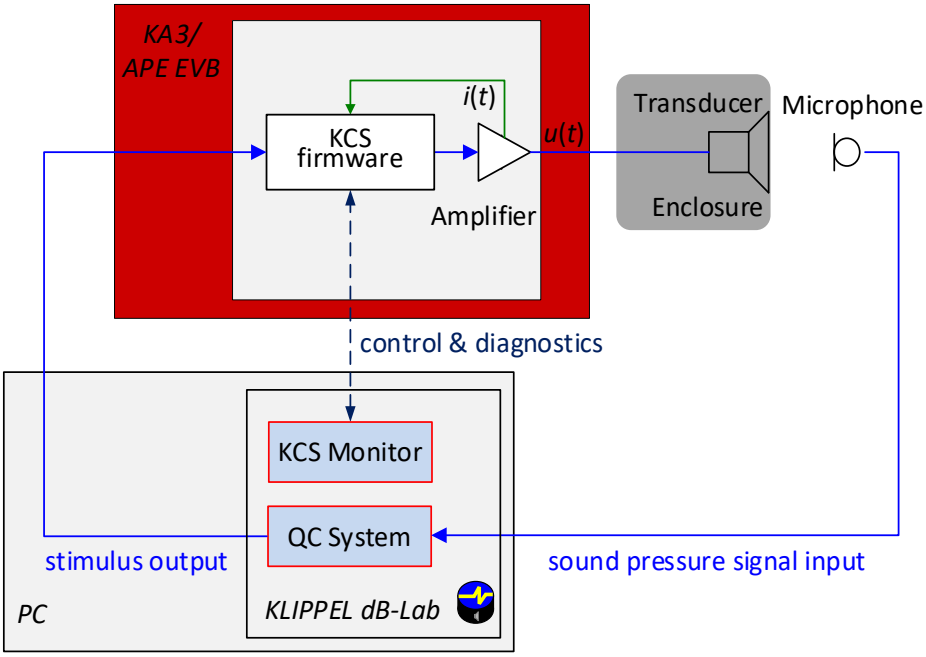


Figure 4: Schematic Diagram of Evaluation Environment

Hardware Connection using KA3 with AMP Card

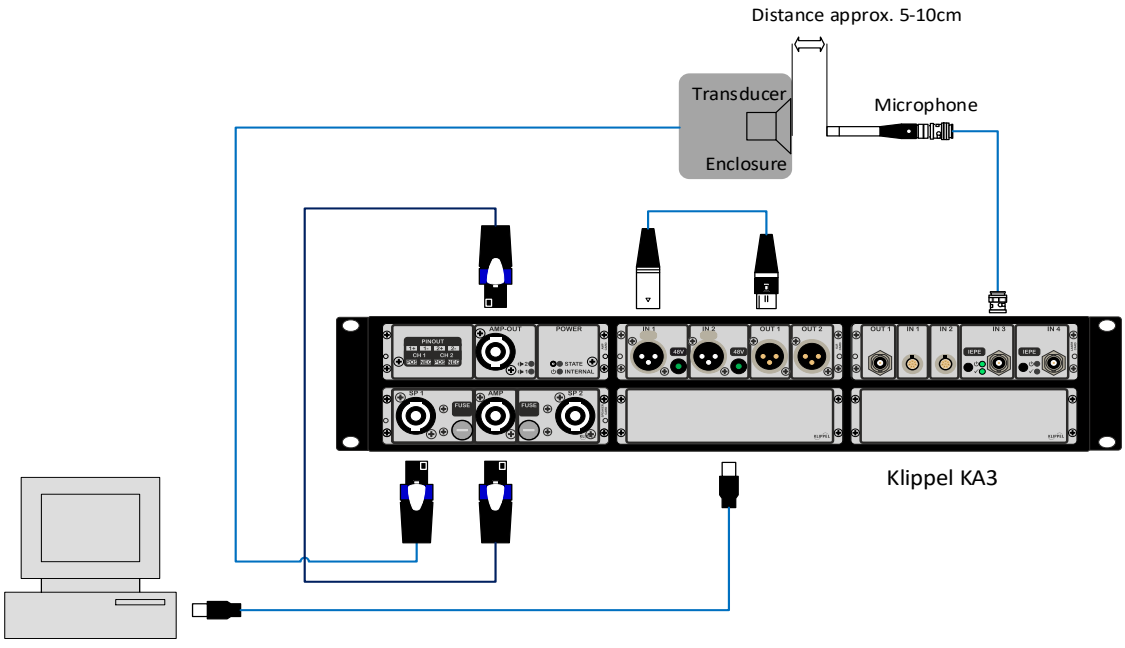


Figure 5: Hardware Connection using KA3 with AMP Card

Hardware Connection using KA3 with external Amplifier

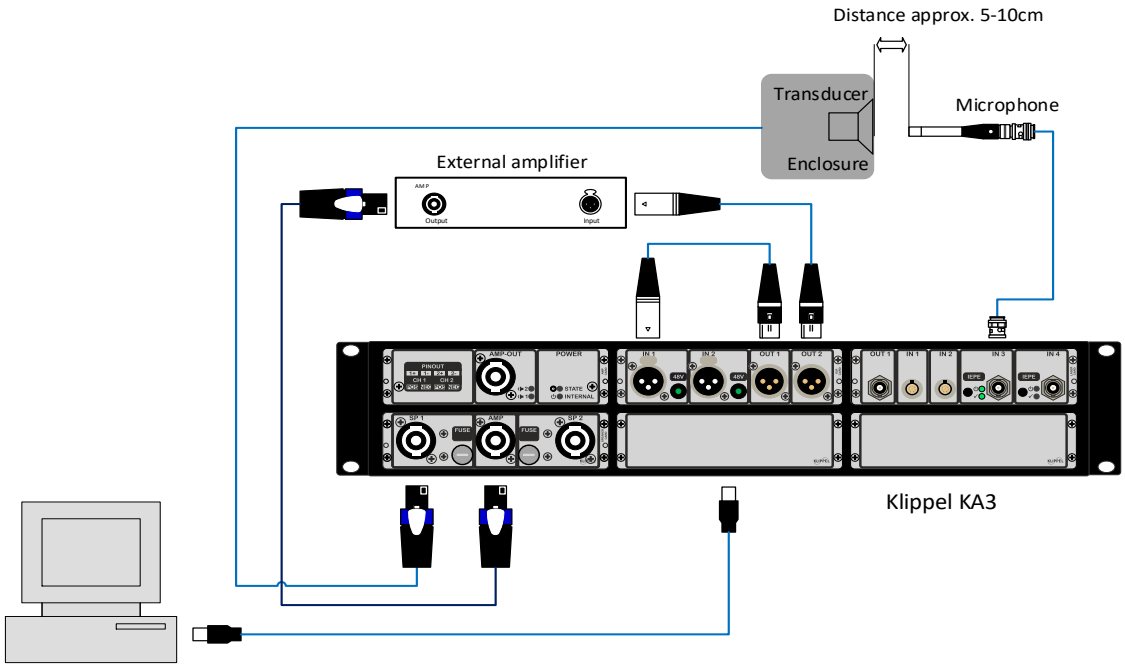


Figure 6: Hardware Connection using KA3 with external amp

Hardware Connection using APE Evaluation Board

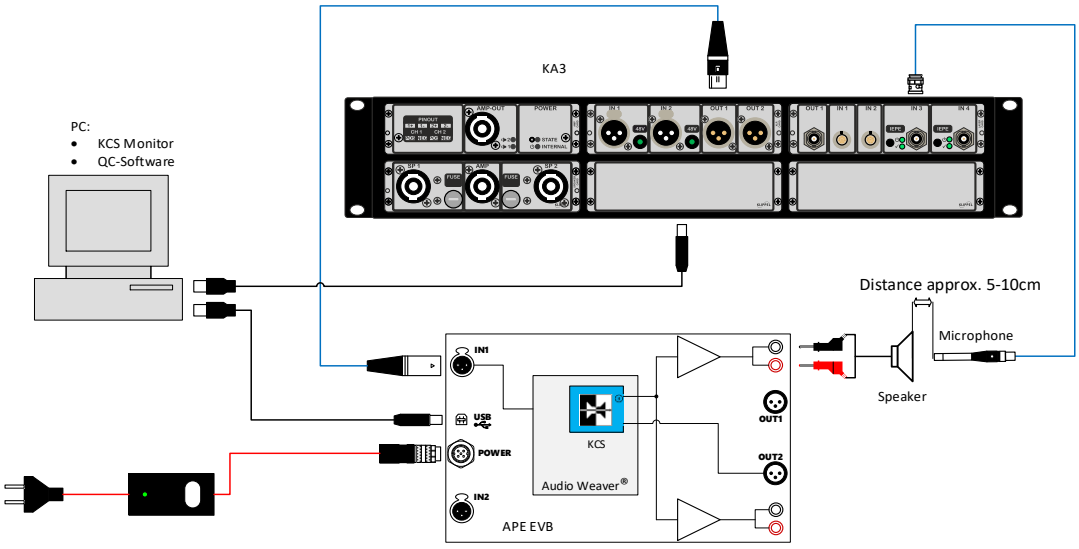
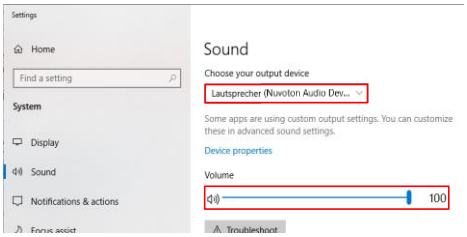


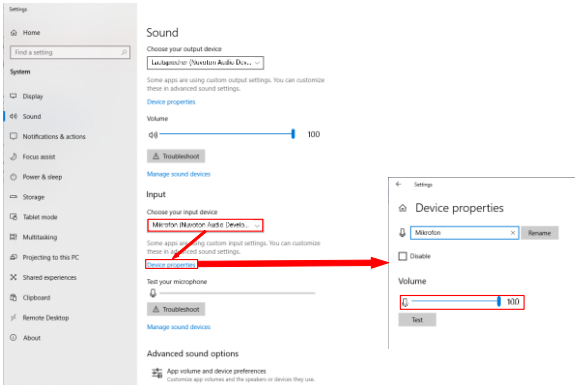
Figure 7: Hardware Connection using APE EVB

4 Software Setup

1. Ensure that the QC measurement device (KA3 or NAD board) is activated.
2. ***(only applicable for Nuvoton device):*** Ensure that the *Nuvoton Audio Development Platform* (*NAD*) is configured as active, default ***output*** device in **Windows sound settings.** Make sure the output is **unmuted** and the volume level is set to **100%**.



3. ***(only applicable for QC measurement with NAD board DMIC):*** Ensure that the NAD board is configured as active, default ***input*** device in **Windows sound settings**. Make sure the input is **unmuted** and volume level is set to **100%**.



4. Install dB-Lab as well as the provided license files and start dB-Lab after successfully performed installation process.
5. Configure the global inputs, outputs and calibrations to be used for QC measurement by performing following steps dependent on the used QC measurement hardware:
    a. **<u>KA3 used as QC input device</u>**
        (1) Select in Menu: *Hardware -> KA3 -> Signal Configuration*
        (2) Select the specific KA3 to be used in device select drop-down menu and ensure that option *Use the Default Settings for this device* is **un-checked**
        (3) Confirm the usage of a device specific custom setting in case the appropriate pop-up is displayed (will not be shown if checkbox was already unchecked in previous step)
        (4) Set *Mic 1,2* Input in Section *QC* to *Laser Card: IN 3,4 (IEPE)*
        (5) Assign a microphone calibration file to *Mic 1 Sensor* by clicking on this input field to open menu and selecting one of the following options for assigning or creating a microphone calibration file:
            a. *Select Sensors (Klippel Presets)* => assign a pre-installed calibration file provided by Klippel for known/approved microphones by selecting appropriate file from subfolder *Microphones* in shown file selection dialog
            b. *Select Sensors* => similar to previous option but an already existing user-created calibration file can be selected

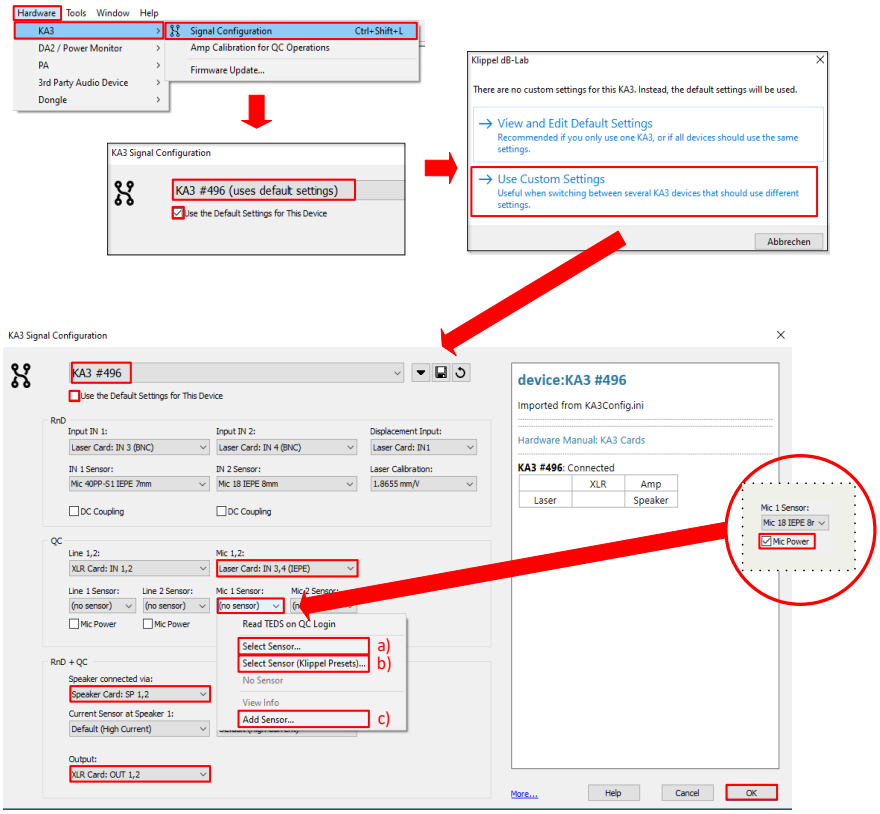
c. *Add Sensor…* => create a new calibration file (on using microphone calibrator or entering sensitivity and maximum sound pressure level manually) and assign this to the input (more *details are available in the dB-lab help => click into Signal Configuration dialog and push F1 to open specific help content on topic calibration)*

(6) Ensure to activate *Mic Power* associated with *Mic 1 Sensor*

(7) Configure *Speaker connected via* in section *RnD + QC* to *Speaker Card: SP 1,2*

(8) Configure *Output* in Section *RnD + QC* to *XLR Card: OUT 1,2*

(9) Push button *OK* to close *Signal C*onfiguration dialog and confirm settings



b. ***NAD board DMIC* used as QC input device**

(1) Select in Menu: *Hardware -> 3rd party audio device -> Select Sensors*

(2) Select *DS: Default Capture* in drop-down list *Device*

(3) **Deactivate** option *Use Default Settings for This Device*

(4) Assign a microphone calibration file to *Channel 01 Sensor by highlighting* this row with a mouse click *and using one of the following buttons to select or create a microphone calibration file for this input:*

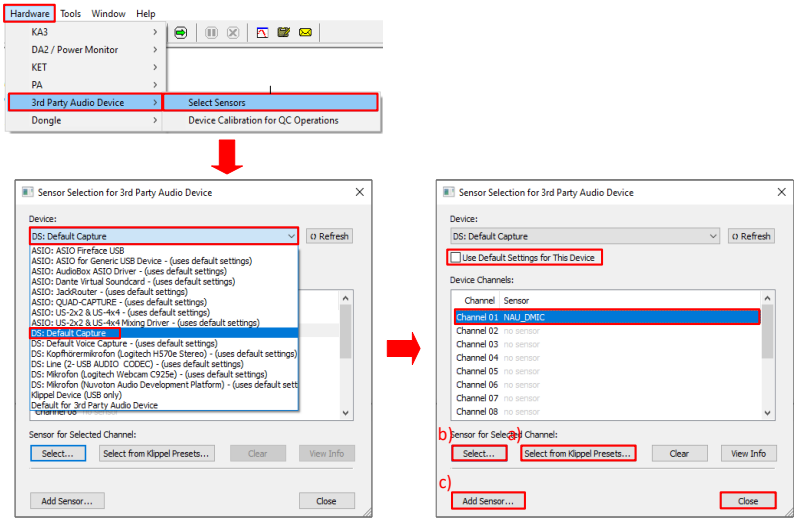
a. *Select Sensors from Klippel Presets…* => assign a pre-installed calibration file provided by Klippel for known/approved microphones by selecting appropriate file from subfolder *Microphones* in shown file selection dialog

b. *Select…* => similar to previous option but an already existing user-created calibration file can be selected

c. *Add Sensor…* => create a new calibration file (on using microphone calibrator or entering sensitivity and maximum sound pressure level manually) and assign this to the input (=> for this process a new dB-Lab instance will be automatically opened => open the properties page of the QC operation of this newly opened database, navigate to tab *QC Settings*, push button *Configure Hardware*. Ensure to un-check *Use Default Devices* and

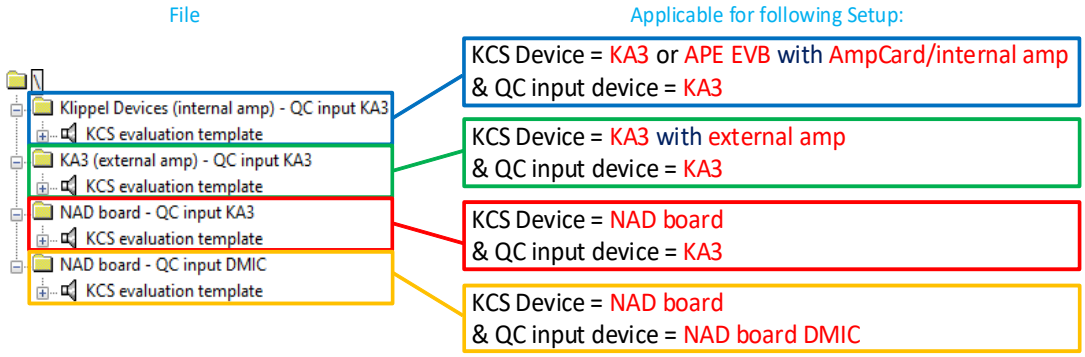
to select devices *DS: Default Playback* and *DS: Default Capture* as output and input device before the login to the QC calibration operation is initiated. Further details about the calibration process are available in the dB-lab help => click into *Signal Configuration* dialog and push *F1* to open specific help content on this topic). Close newly opened dB-Lab instance after calibration process is finished

(5) Close sensor file selection dialog



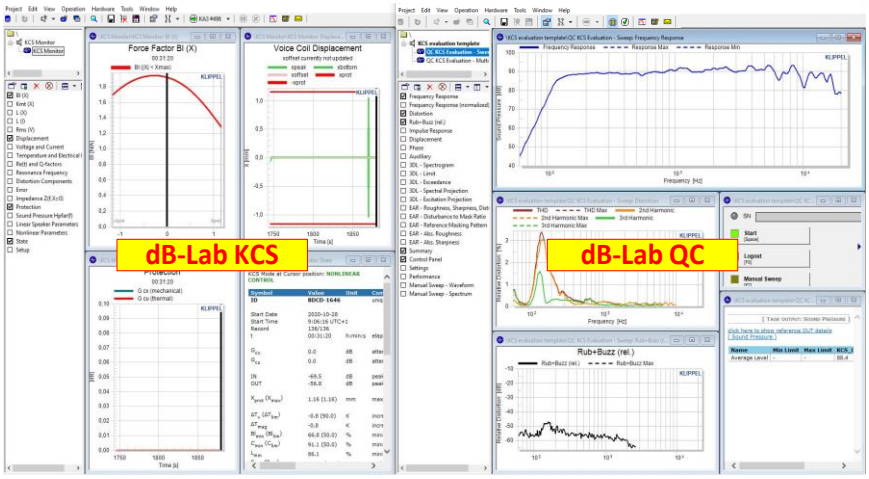
Please use following data in case of NAD board DMIC is used as microphone:
Sensitivity = -42dBFS
Max Level (peak) = 125 dB

6. Open the database ***KCS Evaluation Template.kdbx*** in dB-Lab (dB-Lab instance further called **db-Lab-QC**)
7. **db-Lab-QC**: Select the correct KCS evaluation template object based on your KCS device, amplifier type and QC input device for all subsequent steps of your evaluation process



8. **db-Lab-QC**: Log in to one of both QC operations (dependent on tutorial, see appropriate chapters for details) located below the selected folder by selecting operation and pushing  (Only one active login to a qc operation possible at the same time. Log off from active QC operation by pushing  and log in to other QC operation to switch to that QC operation)
9. Open a second instance of dB-Lab and make sure the KCS Monitor operation belonging to the DUT is running in this dB-Lab instance. (This dB-Lab instance further called ***db-Lab-KCS***).

10. Arrange the windows of both dB-Lab instances side by side



5 Tutorial 1 – Check Setup

Goal: Verify that the hardware and software setup is done correctly.

Required QC template operation: QC KCS Evaluation – Sweep

1. ***db-Lab-KCS***: Ensure that KCS control mode is 

(result window *State*)
2. **db-Lab-QC**: Perform a QC measurement (

) and carefully listen to the audible sound output. All setup steps were done correctly, if short noise signal followed by frequency sweep signal is audible and no error is shown in QC operation summary window.

If error 70 occurs and no signal is audible at all, probably the speaker is not connected or a wrong speaker not matching the ID data is connected, the KCS operation is not running or the audio gain of the KCS operation or the stimulus level of the QC operation is set too low. This error also can occur if the wrong evaluation template not matching the correct hardware setup is used.

If error 70 occurs and only the short noise signal but no sweep signal is audible, probably the microphone is not connected/activated or IEPE/phantom power supply is switched off, a wrong microphone input is configured, the audio gain of the KCS operation or the stimulus level is set too low.

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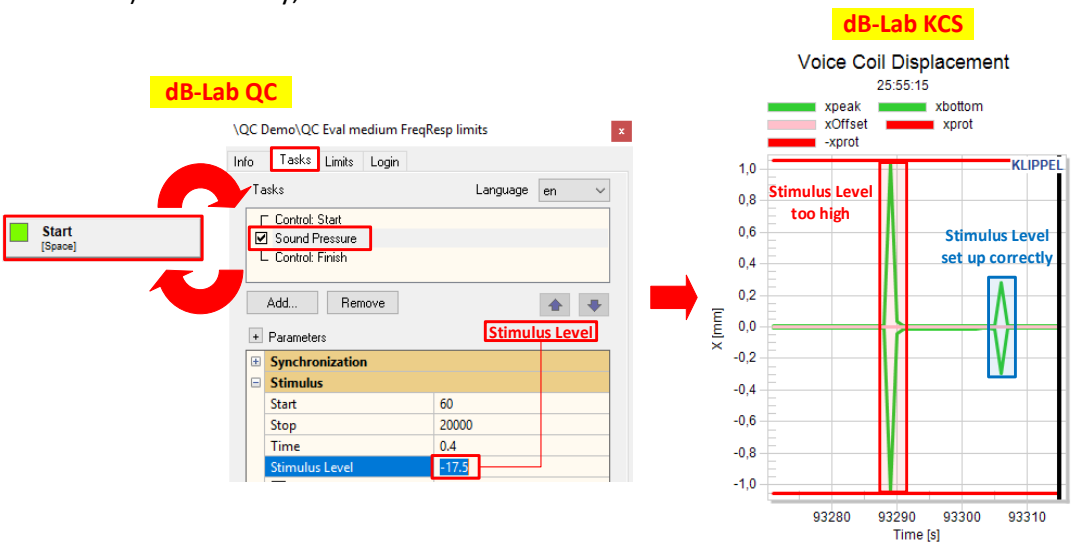
6 Tutorial 2 – Measuring the Frequency Response

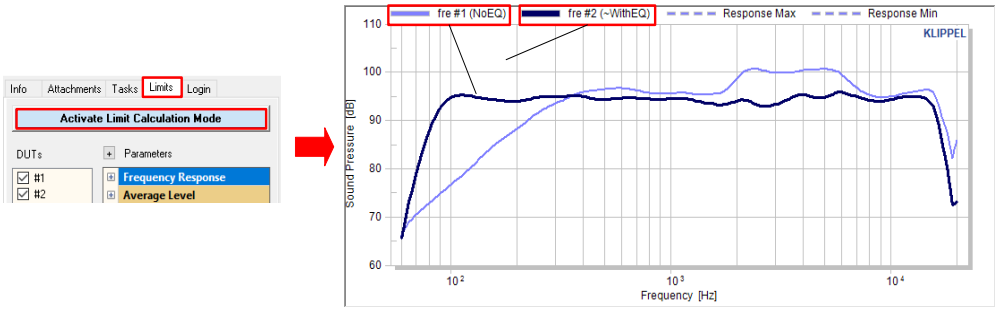
Goal: Measuring the active speaker's frequency response in the small signal domain using the Klippel QC system. This measurement can be used to set up the alignment and equalizer settings.

Required QC template operation: *QC KCS Evaluation – Sweep*

1. ***db-Lab-KCS***: KCS should be turned on (result window *State*: KCS ON).
2. Perform a QC measurement (**db-Lab-QC**: Start [Space]). Make sure that the voice coil displacement is considerably below the mechanical protection limit *xprot* (***db-Lab-KCS:*** see *Displacement* chart). If necessary, reduce the stimulus level of the *Sound Pressure* task.



3. **db-Lab-QC**: The measured frequency response of the system in the small signal domain is shown in result window *Frequency Response*.
4. *(optional)* **db-Lab-QC:** Compare multiple measurements, e.g. taken at different microphone positions or to compare equalizer settings, by using the *Limit Mode* which overlays all measured curves. Navigate to the property page's *Limits* tab and press *Activate Limit Calculation Mode.*



7 Tutorial 3 – Active Speaker Evaluation

Goal: Quick evaluation of the performance of the active speaker with and without KCS in the large signal domain.

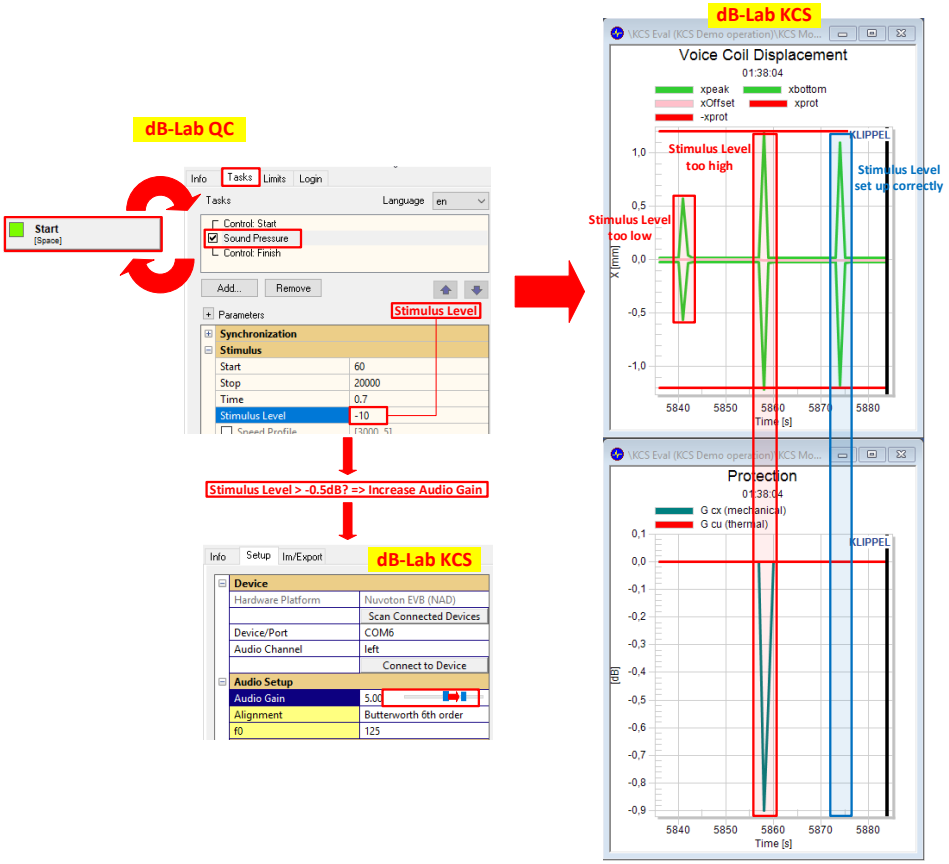
Required QC template operation: *QC KCS Evaluation – Sweep*

Note: Perform this measurement with activated bass boost and equalization, comparable to the target application! Turn off nonlinear audio enhancement algorithms such as compressors and virtual bass as they produce nonlinear distortion, which would make it difficult to interpret the results.

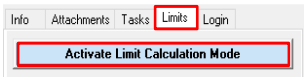
Configure and Perform Measurements

1. ***db-Lab-KCS***: Ensure the KCS is switched on (result window *State*: KCS ON)
2. **db-Lab-QC**: Perform a QC measurement (Start [Space]). Adapt the stimulus level of the task *Sound Pressure* in the property page until the voice coil displacement is close to the protection limit *xprot* (***db-Lab-KCS:*** see *Displacement* chart). Make sure that the protection system stays inactive (***db-Lab-KCS:*** see *Protection* chart).

The stimulus level of the SPL task must not exceed -0.5dB as clipping can occur. Increase the KCS Audio Gain (***db-Lab-KCS***: Property page) if more gain is required.



3. **db-Lab-QC**: Navigate to property page tab *Limits* and press *Activate Limit Calculation Mode* to easily compare measurements.



4. **db-Lab-QC**: Enter text "**ON**" into input field *SN* located in QC control panel and perform a QC measurement.

5. ***db-Lab-KCS***: Switch to KCS-Mode 

.
6. **db-Lab-QC**: Enter text "**OFF**" into input field *SN* located in QC control panel and perform a new measurement.

Important: To get support from Klippel and for the KCS approval process you always need to provide the **QC operation** as well as the appropriate **KCS Monitor operation containing measurement data**.

Evaluating Results

Rub+Buzz (rel.) Curve

Goal: This curve reveals irregular and impulsive distortion caused by e.g. rubbing or bottoming of voice coil, amplifier limiting, etc. This kind of distortion is very critical and must be avoided because of a low audibility threshold.

Evaluation step: Check both *rub+buzz (rel.)* curves shown in result window *Rub+Buzz (rel.).*

Expected result: Neither of the curves exceed the limit of approx. -20dB which indicates high impulsive distortion. If the limit is exceeded, refer to section *How to Treat Rub+Buzz Issues*.

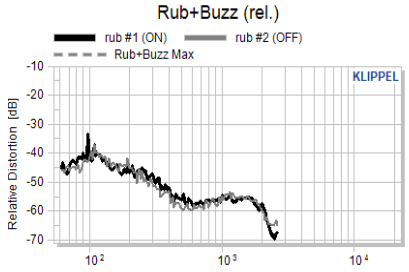


Figure 8:Example Rub&Buzz curves

Distortion Curve

Goal: Verify that the active speaker system including KCS is working as expected. This includes:

- correct hardware connection
- initial KCS data fits to the speaker
- KCS algorithm models the speaker correctly

Evaluation step: Compare the total harmonic distortion curves shown in result window *Distortion.*

Expected result: The THD measured in *KCS ON* mode should be lower than the THD measured with KCS in control mode *KCS OFF + EQ*.

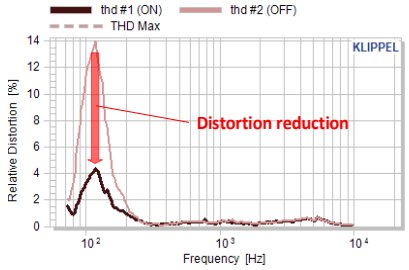


Figure 9: Example THD curves

Frequency Response Curve

Goal: Symmetric speaker nonlinearities cause compression in the acoustical output at high voice coil displacement and/or velocity. Evaluate the KCS linearization feature which compensates these compression effects.

Evaluation step: Compare the frequency response curves shown in *Frequency Response* window.

Expected result: In the frequency range where the voice coil displacement and/or velocity is high, the magnitude of the frequency response in *KCS ON* mode is higher than without KCS. The curve shape is almost identical to the small signal measurement but with a higher level.

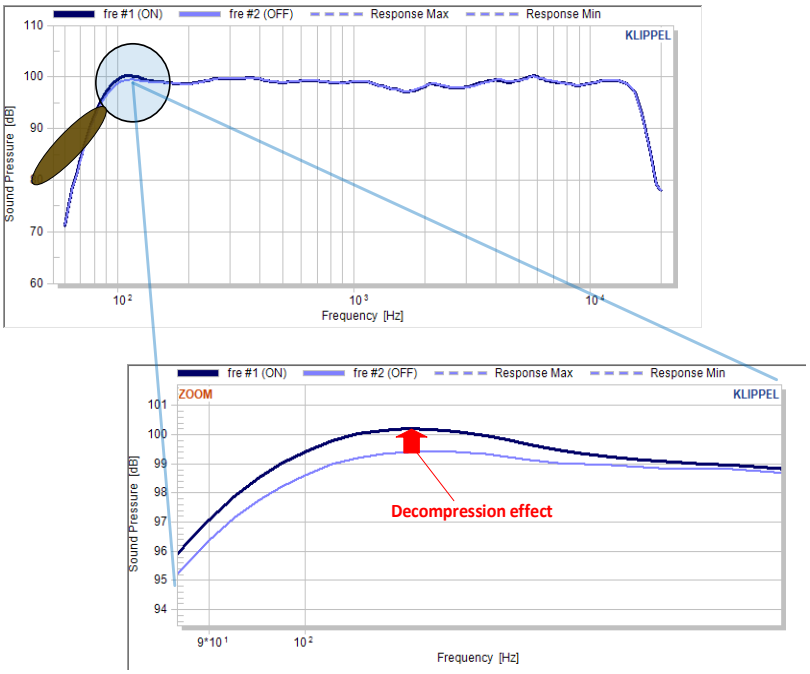


Figure 10:Example frequency response curves

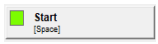
8 Tutorial 4 – Evaluate Mechanical Protection System

Goal: KCS prevents mechanical overload and allows to increase the SPL even if the transducer is already operated at its mechanical limits. This section explains how to evaluate the mechanical protection system.

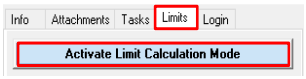
Required QC template operation: *QC KCS Evaluation – Sweep*

Configure and Perform Measurement

1. ***db-Lab-KCS***: Ensure the KCS is switched on (result window *State*: 

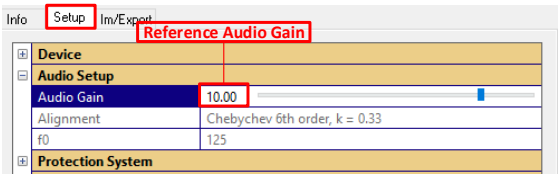
)
2. **db-Lab-QC**: Perform a QC measurement (**db-Lab-QC**: 

). Adapt the stimulus level of the task *Sound Pressure* in the property page until the voice coil displacement is close to the protection limit *xprot*, as explained in ***Tutorial 2 -*** *Configure and Perform Measurements*)
3. **db-Lab-QC**: Navigate to property page tab *Limits* and press *Activate Limit Calculation Mode* to easily compare measurements.

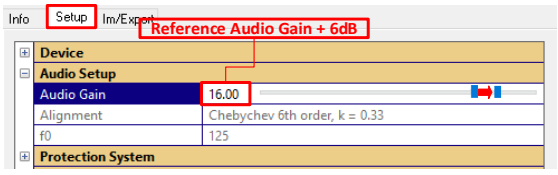


4. **db-Lab-QC**: Enter an identifier for the reference measurement, e.g. "**Ref**", into the input field *SN* located in QC control panel and perform a QC measurement.

5. ***db-Lab-KCS***: Open the property page and memorize the actual *Audio Gain*. This value will be referenced later as *Reference Audio Gain*.

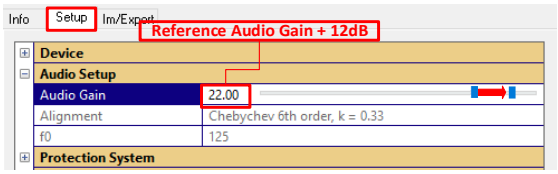


6. ***db-Lab-KCS***: Increase the *Audio Gain* by **6dB**



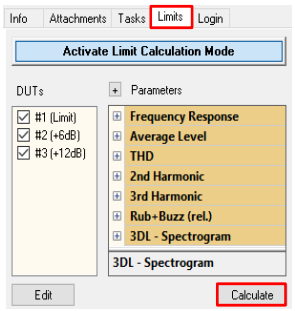
7. **db-Lab-QC**: Enter "**+6dB**" into input field *SN* located in QC control panel and perform a QC measurement

8. ***db-Lab-KCS***: Increase "*Audio Gain*" by a further **6dB** (Resulting Audio Gain = Reference Audio Gain + 12dB)



9. **db-Lab-QC**: Enter text "**+12dB**" into input field *SN* located in QC control panel and perform a QC measurement

10. **db-Lab-QC**: Push button *Calculate* to update the values and curves displayed in the result windows



Important: Reset the KCS Audio Gain (***db-Lab-KCS***) to the *Reference Audio Gain* after the measurement.

Evaluating Results

Frequency Response Curve **(dB-LAB-QC)**

Goal: Evaluate the influence of the protection system on the system's frequency response.

Evaluation step: Compare the three frequency response curves shown in result window *Frequency Response.*

Expected result: Once the modeled displacement reaches the protection limit *xprot*, an adaptive high pass filter with variable cut-off frequency activates to prevent mechanical overload. The high frequency SPL is still increased in 6dB steps.

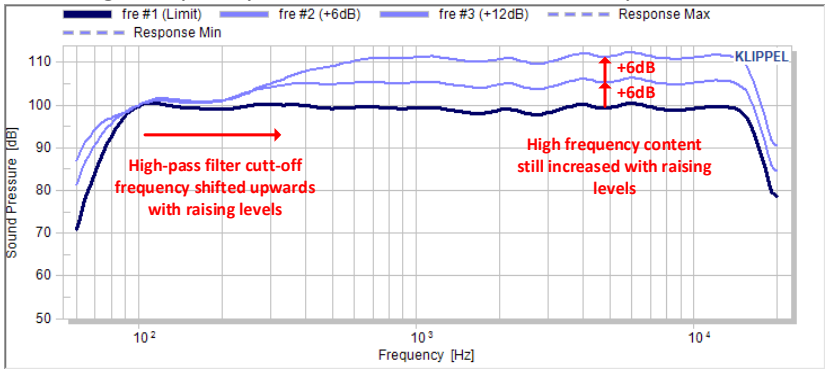


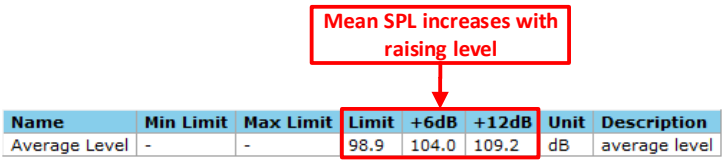
Figure 11: Example frequency response curves

Mean Sound Pressure Level **(dB-LAB-QC)**

Goal: Evaluate that the mean SPL can be further increased although the speaker already operated at its mechanical limits.

Evaluation step: Compare the sound pressure level determined during the three measurements shown in result window *Summary.*

Expected result: The mean sound pressure levels of the subsequently performed measurements increase on higher gain levels, even when the protection system was active.



Name	Min Limit	Max Limit	Limit	+6dB	+12dB	Unit	Description
Average Level	-	-	98.9	104.0	109.2	dB	average level

Figure 12: Example mean SPL values

Displacement and Mechanical Protection Curves (dB-LAB-KCS)

Goal: Evaluate that the mechanical protection of the KCS ensures that the maximum defined working range is not exceeded and no mechanical overload situation occurs.

Evaluation step: Check the displacement curves *xpeak*/*xbottom* recorded during the three QC measurements and the appropriate mechanical protection curve *G cx (mechanical).*

Expected result: The displacement did not exceed the defined working range limit *xprot* during the three QC measurements. The attenuation of the protection system agrees approx. to the attenuation at low frequencies (see *Frequency Response Curve* in **dB-Lab-QC**).

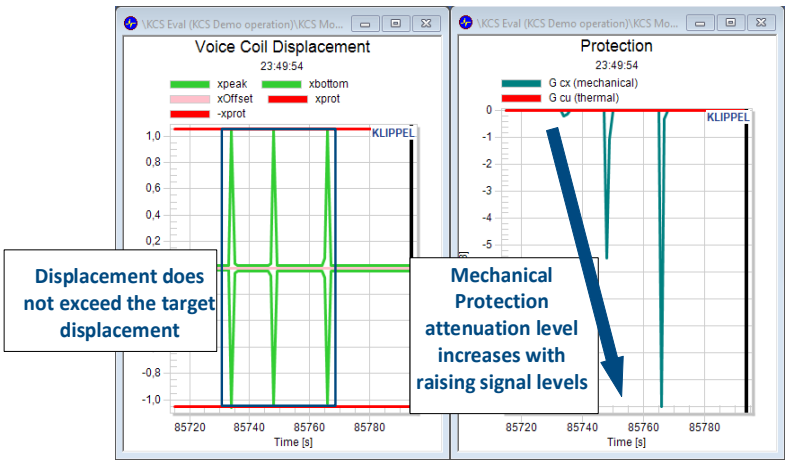


Figure 13: Example Voice coil displacement and mechanical protection curve

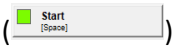
9 Tutorial 5 – Multi-Tone Distortion

Goal: Evaluate the reduction of harmonic and intermodulation distortion in the large signal domain on applying a multi-tone signal.

Required QC template operation: *QC KCS Evaluation – Multi-tone*

Configure and Perform Measurements

1. ***db-Lab-KCS***: Ensure the KCS is switched on (result window *State*: 

)
2. **db-Lab-QC**: The stimulus level of the task *Multi-tone needs to be adapted* similar as done with task *Sound Pressure* in *Tutorial 2 – Active Speaker Evaluation* to achieve a maximum voice coil displacement without activating the mechanical protection. Therefore, perform a QC measurement (

) and adapt *Stimulus Level* in the property page of the Multi-tone task until the voice coil displacement is close to the protection limit *xprot* (***db-Lab-KCS:*** see *Displacement* chart). Make sure that the protection system stays inactive (***db-Lab-KCS:*** see *Protection* chart).

The stimulus level of the Multi-tone task must not exceed -0.5dB as clipping can occur. Increase the KCS Audio Gain (***db-Lab-KCS:*** *Property page*) if more gain is required.

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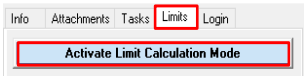
3. **db-Lab-QC**: After configuration of sufficient stimulus level, navigate to property page tab *Limits* and press *Activate Limit Calculation Mode* to easily compare measurements.



4. **db-Lab-QC**: Enter text "**ON**" into input field *SN* located in QC control panel and perform a QC measurement.

5. ***db-Lab-KCS***: Switch to KCS-Mode 

.

6. **db-Lab-QC**: Enter text "**OFF**" into input field *SN* located in QC control panel and perform a new measurement.

Evaluating Results

Multi-tone Distortion Curve

Goal: Speaker nonlinearities create harmonic and intermodulation distortion on applying stimulus signal containing multiple frequencies which are compensated by KCS.

Evaluation step: Compare the multi-tone distortion curves shown in *Multi-tone Distortion* window.

Expected result: The distortion measured in *KCS ON* should be reduced compared to the *KCS OFF + EQ* measurement.

Frequency Response Curve (also shown in result window Multi-tone Distortion*)*

Goal: As already discussed in *Tutorial 3 – Active Speaker Evaluation* symmetric speaker non-linearities will cause compression in the acoustical output at high voice coil displacement and/or velocity. Of course, the KCS linearization feature also compensates these compression effects in case of more complex stimulus signals are applied to KCS.

Evaluation step: Compare the frequency response curves also shown in the *Multi-tone Distortion* window.

Expected result: In the frequency range where the voice coil displacement and/or velocity is high, the magnitude of the frequency response in *KCS ON* mode is higher than without KCS.

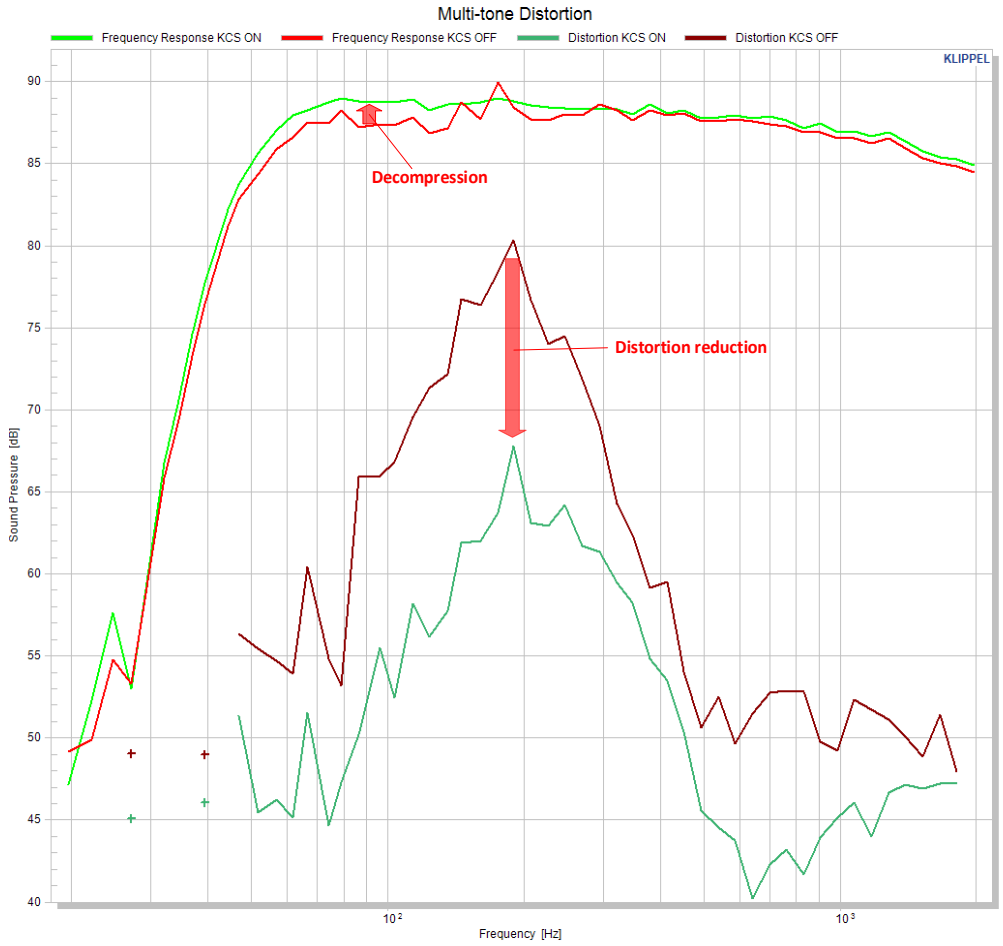


Figure 14: Example frequency response and multi-tone distortion curves

10 How to Treat Rub+Buzz Issues

Goal: Identify and eliminate possible root causes for detected Rub&Buzz issues.

To determine root causes of the Rub&Buzz it is necessary to check the QC measurement and the corresponding KCS Monitor operation at the exact timestamp at which the stimulus was applied to the speaker.

Note: You can set the time cursor in any of the time-based curves of the KCS Monitor operation to get specific information for that timestamp by pressing [CTRL]+clicking in the window at the desired time.

Root Cause	Indication	Possible Solutions
Transducer defect or overload	• Rub+Buzz is present *KCS OFF + EQ* mode • speaker is operated within the defined working range (*xprot* is not exceeded) • level of environmental noise sufficiently low • amplifier/output is not clipping • input is not clipping • acoustical output level is sufficiently high	• Use KCS Monitor parameter *Excursion Limit* to reduce the voice coil's working range • Replace the speaker by a speaker without rub+buzz issues
Amplifier/ Output limiting	• Warning *Output Clipping* in KCS Monitor **OR** • KCS Monitor: *OUT* (*State* window) is very close to 0dB during applying stimulus	• Reduce usable working range of speaker by decreasing KCS Monitor parameter *Excursion Limit*
KCS Input clipping	• Warning *External input signal is limiting* displayed during applying stimulus **OR** • KCS Monitor: *IN* (*State* window) is very close to 0dB during applying stimulus	• If IN is close to 0dB reduce the input level (e.g. reduce gain in A6 tool if used) • If IN is not close to 0dB reduce the Audio gain in KCS Monitor property page
Environmental Noise	• Bad matching rub+buzz curves of subsequent measurements	• Reduce the environmental noise
Acoustical output too low	• Acoustical output of the speaker is barely audible • Noisy Frequency Response curve	• Increase the stimulus level
KCS Protection System	• None of the above reasons apply	• If critical, increase the protection delay in KCS Monitor or reduce bass boost. Usually this kind of

	• ***Reason:*** The rub+buzz measurement is very sensitive and reveals small changes of the signal created by the protection system.	distortion is not audible with music/speech signals if protection delay is greater than 2ms.