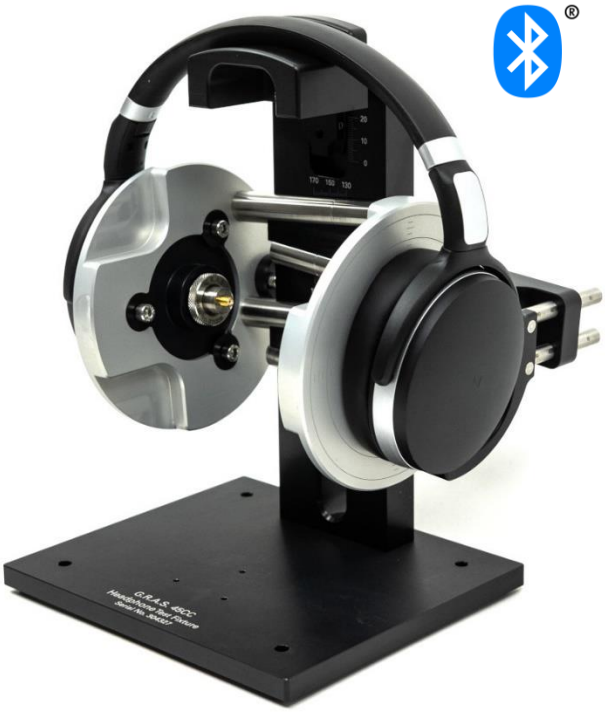
Quality Control of Headphones AN73

Application Note for the KLIPPEL ANALYZER SYSTEM

Document Revision 1.5

SCOPE

- Fast and reproducible quality control in lab or end of production line
- Over- and on-ear headphones and headsets (also applicable to earphones)
- Passive, digital (USB) and wireless devices (*Bluetooth*® wireless technology enabled products)
- Microphone test
- Noise attenuation (passive or ANC)
- KLIPPEL QC software framework (also available in R&D framework)
- *KLIPPEL Analyzer 3* or *Production Analyzer*
- *G.R.A.S. 45CC* headphone test fixture dedicated to quality control



OVERVIEW

Testing head- and earphones can be a challenging and time-consuming task that requires experience and careful handling in order to obtain meaningful and reproducible results. In an R&D context, such tests are covered by various standards (e.g. IEC 60268-7) and a multitude of dedicated test fixtures including ear and mouth simulators are available on the market for this purpose. Ear (as well as head and torso) simulators are used to provide a defined acoustical load and expected target response at the ear-drum reference point (DRP) according to ITU-T P.581.

However, such design-related testing approaches are hardly applicable in high-volume quality control. Other requirements like simple handling, speed, stability, robustness against ambient noise and reproducibility are much more important in end-of-line testing following the ultimate goal of distinguishing good from bad units reliably.

This application note focuses on those requirements and provides approaches for testing various types of headphones and headsets exploiting the features and flexibility of the *KLIPPEL QC Software* framework, Klippel Analyzer hardware and the *G.R.A.S. 45CC* headphone test fixture dedicated to headphone quality control.

Out of many possible test scenarios, three different use cases are addressed

- passive headphone,
- digital USB headset,
- *Bluetooth*® enabled headphone with active noise control (ANC).

Focusing on the challenges of testing digital and wireless devices, topics like connectivity, solutions for handling different audio devices and dealing with unknown and varying playback delays are provided.

Other test scenarios may be derived based on the information provided. The suggested approaches may also be applied to earphones using other dedicated test fixtures.

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1 Overview

1.1 How to Use this Application Note

This document addresses three particular test scenarios for different types of headphones and headset in detail. Pick one of the use cases that corresponds best to the device under test and continue with the corresponding chapter:

- *Passive Headphone*
- *Digital Headset (USB)*
- *Bluetooth Enabled Headphone with ANC*

Before starting with practical testing, it is recommended to read the hard- and software *Requirements* and follow the instruction given in section *Preparation* carefully.

Some continuative topics related to headphone testing are addressed in section *Further Topics*.

1.2 Results

In QC, the goal is to provide critical and meaningful test parameters to ensure consistent product quality and specification sheet compliance translated to the EOL test:

Headphone parameters

- Frequency response of left and right channel
- Sensitivity (average or single frequency level)
- Inter-channel difference (left-right balance)
- Polarity
- Harmonic distortion (THD, 2^{nd}, 3^{rd}, ...)
- Rub & buzz distortion
- Impedance magnitude (for passive DUTs)
- Minimal impedance (for passive DUTs)

Microphone parameters (headset)

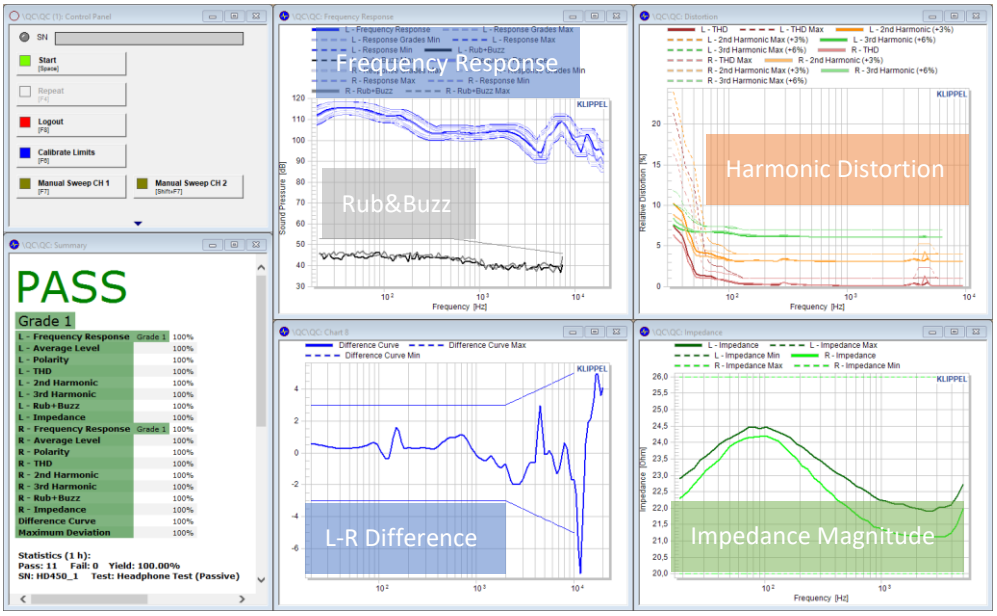
- Frequency response
- Sensitivity
- Harmonic distortion (THD)
- Opt: noise/impulsive distortion (*Rub & Buzz*)

Attenuation

- Sound attenuation over frequency (passive or *ANC*)

A detailed discussion of the results is done in the application sections.

The following example screenshot shows the operator view for a passive headphone test realized with the KLIPPEL QC Standard software.



2 Passive Headphone

2.1 Overview

This application deals with testing analog stereo headphones with 3.5 mm or 6.35 mm TRS phone connector focusing on impedance test, frequency response, channel difference, distortion and rub & buzz.

It is a standard closed loop test setup where the KLIPPEL Analyzer is both playback (test signal) and input device (microphone input).

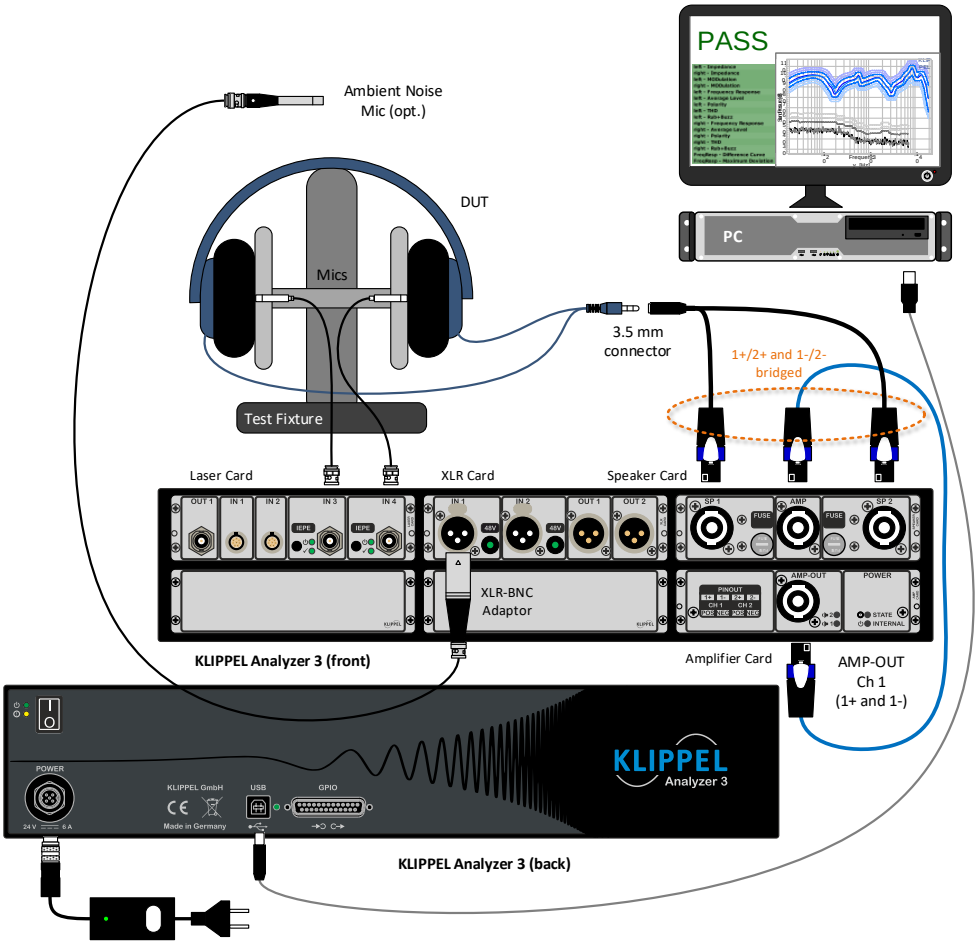
The test fixture used here is the *G.R.A.S. 45CC-2* without ear simulator. The *RA0039* may be added to provide standardized acoustical load conditions to the DUT.

Follow the steps in section *Preparation* carefully before starting with this section.

2.2 Hardware Setup

For general hardware requirements and necessary components refer to section *Requirements*.

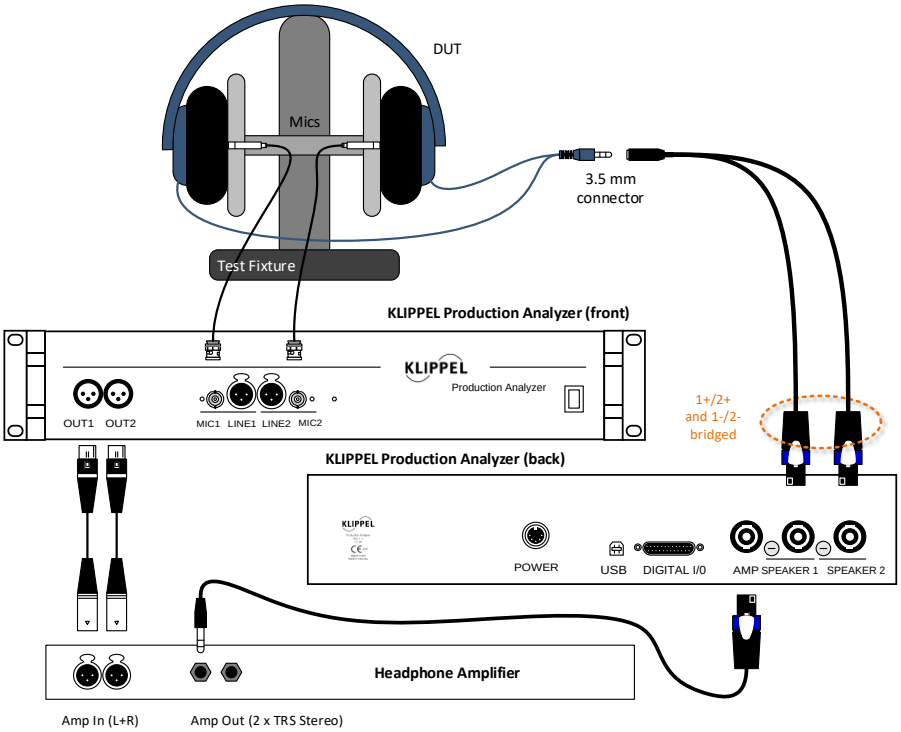
KA3 with Amplifier Card	The sketch below visualizes the typical setup for passive headphone testing using KA3 hardware. Please read section *Connecting Passive Stereo Headphones* carefully before continuing.



- Connect the *KA3* to the PC using the USB cable provided by KLIPPEL
- Connect the *Amplifier Card* output to the *AMP* input of the *Speaker Card* (mind correct orientation of mono cable with one-sided bridge

  Attention: The standard four-wire stereo *speakON* amplifier cable provided by KLIPPEL is not suitable for driving headphones with common ground with stereo class D amplifiers. However, it may be used after modification for mono operation.
- Connect the headphone jack to the outputs *SP1* and *SP2* of the *Speaker Card* using the custom adaptor cable
- Connect the microphones of the test fixture to *IN3* and *IN4* of the *Laser Card*
- Optional: connect the ambient noise microphone to IN1 of the XLR Card (use an XLR-BNC adaptor for microphones with IEPE supply)

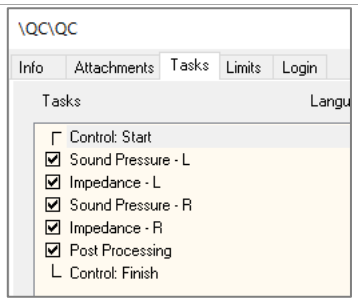
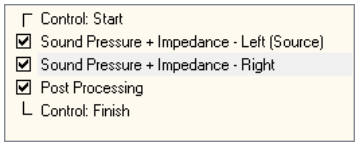
Production Analyzer with External Amplifier	The setup described above may be realized with the *PA* hardware in a similar way using an external headphone amplifier and an optional IEPE mic supply in order to use 3 microphones in total (ambient noise), one connected to the *Line* input of the analyzer.



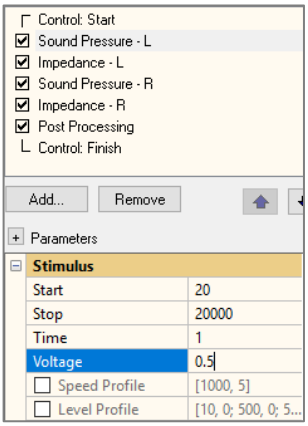
- Connect the *PA* to the PC using the USB cable provided by KLIPPEL (not displayed)
- universal stereo audio amplifier (not displayed)
  - set the amplifier to stereo or parallel mode
  - connect PA OUT1 to the amplifier input 1
  - connect single channel amplifier output to the AMPLIFIER input of the PA; the 2+ and 2- amplifier cable wires must be connected to 1+ and 1-
- headphone amplifier (e.g. Lake People F388 S)
  - Connect both outputs OUT1/2 of the PA to the stereo inputs of the headphone amplifier
  - Connect the stereo output of the amplifier to the AMPLIFIER input of the PA (custom amplifier cable 3 pole jack to NL4 speakON provided by Klippel)
- Connect the headphone jack to the outputs *Speaker 1* & *2* outputs of the *PA* using the custom adaptor cable
- If no ambient noise microphone is used, connect the microphones of the test fixture to *MIC1* and *MIC2* of the *PA* as displayed
- Otherwise:
  - connect the first microphone of the test fixture to *MIC1* input of the *PA*
  - connect the second test fixture microphone to the external microphone supply/preamp (activate 10 dB boost if available)
  - connect the output of the supply IN1 of the XLR Card (use an XLR-BNC adaptor for microphones with IEPE supply)
  - **Note**: it is necessary to calibrate the whole signal chain with a sound calibrator, especially when an additional gain stage is used
  - connect the ambient noise microphone of the test fixture to *MIC2* input of the *PA*

2.3 Test Sequence

Several test templates for passive headphones are provided with this application note or your KLIPPEL software. Create a new test based on the template *Passive Headphone* or *Passive Headphone (Fast)* and login via *QC Start Engineer* or open the database and press the green arrow in the task bar.

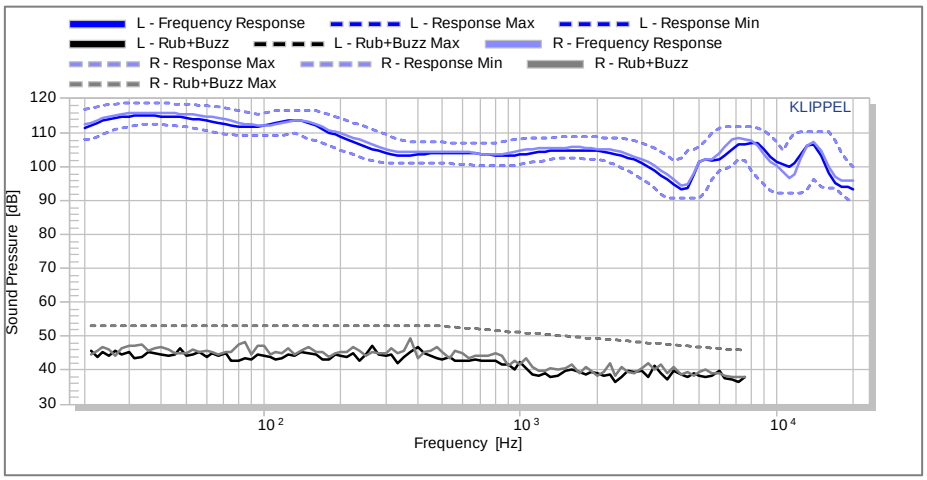
Passive Headphone	This test sequence contains 5 tasks for testing sound pressure response (audio range) and impedance individually for left and right channel. *Difference* is a post-processing task that calculates the deviation between the fundamental frequency response of both channels.  *Note: Executing this sequence requires a QC Standard license due to the number of tasks. For QC in R&D framework, the sequence may be split into two separate operations (Impedance, Sound Pressure + Diff) to handle the restriction of 3 tasks per test.* *Impedance tasks may be removed in case only acoustical parameters shall be measured.*
Passive Headphone (Fast)	The *Fast* version of the test sequence uses combined *SPL+IMP* task to measure both sound pressure and impedance characteristic simultaneously with a single sweep signal.  In case KA3 hardware is used, the *Signal Data Sharing* feature allows measuring both channels simultaneously for time critical testing. The option is active by default but may be deactivated. *Note: The Difference task is not operable with QC Basic license. However, you may select and remove the task from the sequence.*

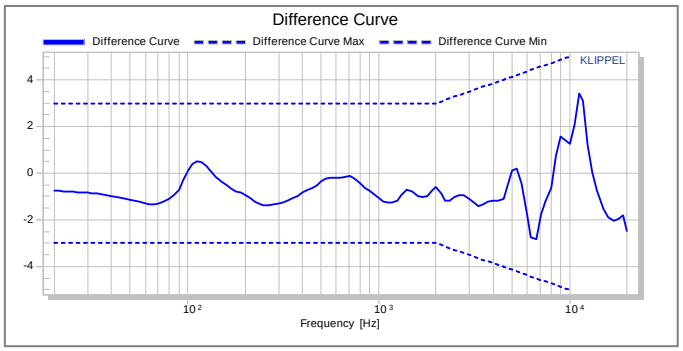
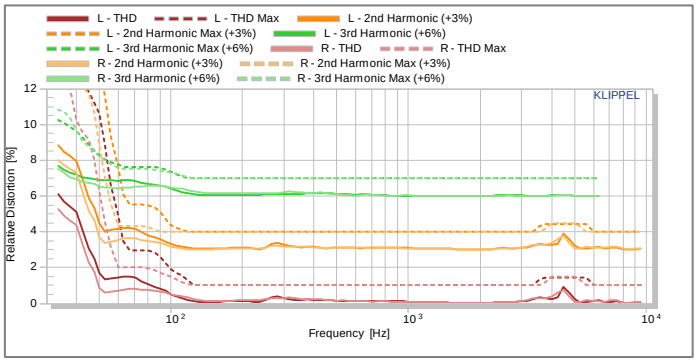
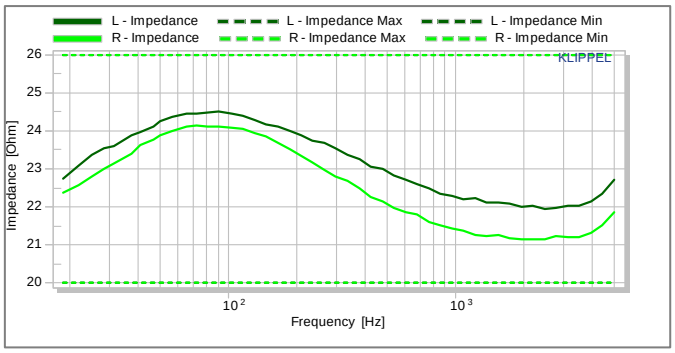
2.4 Adjust Settings

Input Routing	Adjust the input routing (*Test Sensor* L/R as well as opt. *Noise Sensor*) of the *Sound Pressure* tasks according to the actual analyzer and microphone setup used. The provided templates are preconfigured for use with KA3 and ambient noise microphone.
Voltage	For the *Sound Pressure* task, this parameter specifies the sinusoidal RMS voltage at the amplifier output considering the measured open-circuit gain of the amplifier (card).  The voltage should be high enough to provide sufficient signal-to-noise ratio in the acoustic response as well as sufficient excitation for potential defect and distortion mechanisms. Test voltage may also be derived from standard values as defined by IEC 60268-7 such as rated source e.m.f., characteristic voltage (94 dB at 500 Hz) or 1 mW input power equivalent voltage. *Note: Parameter Level Profile can be used to boost the stimulus signal and thus improve poor SNR in certain frequency ranges.* *The EQA module may be used to automatically determine the characteristic voltage or to control the exact voltage at the DUT terminals under load conditions. Refer to section Adjusting Target SPL for more information.* *Attention: Most of the standard parameters require defined measurement conditions that are not fulfilled using test fixtures and other setups than specified in the standard.* There are no general guidelines for the voltage setting of the individual impedance measurement (RMS voltage of multi-tone stimulus). A too low voltage may result in a noisy impedance magnitude. Nonlinear effects at higher voltages are usually less critical.
Frequency Range	The sound pressure measurement should cover at least the rated frequency range of the tested device. The default setting covers the standard audio range from 20 Hz to 20 kHz. Adjust *Fmin* or *Fmax* in the *Stimulus* properties of the *Sound Pressure* tasks, if required. For the left-right balance test (Difference task) it may be necessary to limit upper or lower frequency range in the *Difference Curve* limit settings.
Ambient Noise Detection	In the default settings of the test templates, ambient noise detection is activated. If you are using QC Basic license or no ambient noise microphone is connected, deactivate this option. If a PNI license is available, further ambient noise settings are available (e.g. *Auto Repeat*) that may be activated/configured. Refer to *PNI* Manual for more information.

	For optimal performance, it is strongly recommended to measure the typical passive sound attenuation of the tested device mounted on the test fixture in order to replace the default setting “in Box Enclosure” assuming 15 dB attenuation. Refer to section *Measurement of Ambient Noise Attenuation* for more information.

2.5 Results

Frequency Response	In the *Frequency Response* window, both channel’s (smoothed) fundamental frequency responses are displayed. The curve colors can be edited in the task’s display settings in order to separate the left and right channel results visually.  In this example, the limits for both channels differ because they are based on reference DUTs recorded in *Limit Calculation Mode*. Thus, systematic differences between both channels can be considered. In order to apply equal limits for both channels, absolute limit definition may be used (e.g. copy calculated curve of one channel and paste it as limit for second channel). *Note: Normalized display modes are available to display the frequency response deviation from a golden reference unit, the reference average or relative to the Average Level. Also, floating limits are applicable to evaluate shape of the response curve instead of absolute level. Refer to QC User Manual for more information.*
Rub & Buzz	*Rub & Buzz* reflects higher order, impulsive distortion as caused by most defects of the transducer and other irregularities in the playback chain. The result curves for both channels are also plotted in *Frequency Response* window. In this example, absolute limits have been used that approximate the typical (shifted) noise floor of a typical reference unit. Relative (shifted) limits may also be applied, instead but will result in a less smooth curve.
Average Level (Sensitivity)	The single value result *Average Level* is derived from the measured Frequency Responses. Using default settings, it reflects the mean fundamental SPL in the complete measured frequency range. However, the frequency range may be restricted (or even limited to one frequency, e.g. 500 Hz) using property *Average Level – Frequencies*. [TASK OUTPUT: SOUND PRESSURE - R] Name | Value | Min Limit | Max Limit | Unit | Description Average Level | 110.0 | 106.9 | 112.9 | dB | average sound pressure level [TASK OUTPUT: SOUND PRESSURE - L] Name | Value | Min Limit | Max Limit | Unit | Description Average Level | 110.1 | 106.9 | 112.9 | dB | average sound pressure level

L-R Balance (Difference)	The *Difference Curve* reflects the spectral balance (deviation) between the *Frequency Responses* of left and right channel, calculated by the *Difference Task* (post-processing). Both, the frequency-wise deviation and the maximal deviation may be tested.  In this example, the tolerance has been slightly widened above 2 kHz and limited to frequencies lower than 10 kHz because the evaluation of high frequencies can be difficult and highly depends on modal transducer behavior and headphone positioning accuracy. *Note: Difference task is not available for QC Basic license*
Polarity	The polarity check is based on the acoustic phase response at low frequencies, relative to the phase of the reference units. This test is robust against small phase variation and detects wrong polarity (180° phase shift) reliably.
Harmonic Distortion	Relative harmonic distortion such as Total Harmonic Distortion (THD), 2nd and 3rd harmonic for left and right channel are displayed in result window *Distortion*. For visual separation, the 2nd and 3rd order HD curves are shifted by 3 % and 6 % respectively. This can be adjusted or deactivated in the Display properties of the *Sound Pressure* task.  Relative distortion may be calculated relative to isolated fundamental (IEEE) or total harmonic signal (IEC) as well as relative to average level in order to have less impact of peaks and dips in the frequency response.
Impedance	In result chart *Impedance*, the impedance magnitudes of the left and right channels are displayed.  Absolute limits may be set up in a way that it is ensured that the nominal impedance is above 80 % of the rated nominal impedance. The effective impedance magnitude of the complete headphone on the test fixture is often

highly damped and may represent a complex electro-acoustic system. Therefore, Thiele-Small transducer parameter measurement is not applicable, mostly. However, DC resistance (*Re*) measurement or minimal impedance may be tested (see *QC Manual - Impedance Values*).

[TASK OUTPUT: IMPEDANCE - L]

Name	Value	Unit	Description
Min Impedance (2472 Hz)	21.9	Ohm	value extracted from impedance magnitude

2.6 Limit Calculation

Relative Limits (Golden DUTs)

Since the whole test approach is dedicated to requirements of quality control, the result parameters are not necessarily evaluated on an absolute scale like standard conform results obtained under normative conditions.

For this reason, a typical strategy for generating reasonable result parameter limits under QC test conditions is based on approved reference DUTs (*Golden DUT*). Tested and verified under lab conditions, one or more of these physical units are measured in the QC test station in order to derive relative limits.

Alternatively, parameters such as *Frequency Response* may be normalized in order to monitor the deviation from the reference unit. Other parameters (e.g. THD) can be measured relative to the frequency response or average level.

The Golden DUT can be used to adjust limits in case of systematic drifts or changed conditions.

Find more information in QC User Manual sections Reference units, Limit Calculation or Golden Unit Handling.

Identical Limits for L/R Channel

Since the left and right channels of the DUT are tested by separate *QC Tasks*, the limit calculation is independent for both channel's responses. In order to use identical limits, absolute limit definition can be used instead of relative shift that is based on the left and right channel's individually measured reference data.

Also, one or more identical reference responses may be imported that replace the recorded reference DUTs for relative limit calculation.

Find more information in QC User Manual sections Absolute Limits or Limit Import.

3 Digital Headset (USB)

3.1 Overview

In contrast to passive headphones, digital headphones usually do not provide a signal input or output for direct test signal playback or microphone response recording by the analyzer. Digital-analog conversion and amplification is done by the active electronics integrated in the headset. Only a digital interface is provided, such as a USB interface.

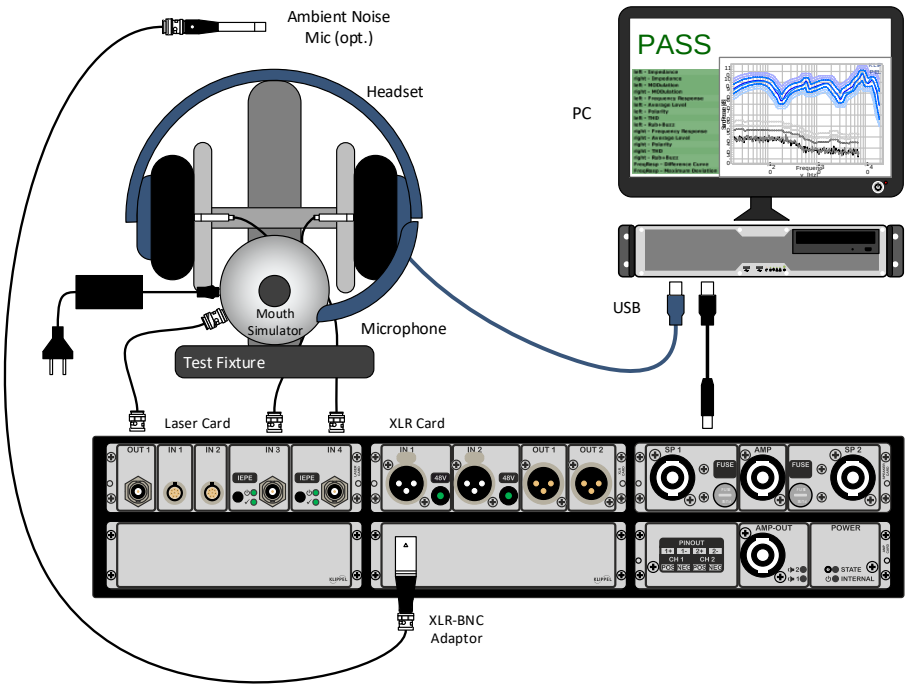
This application focuses on testing both, the sound pressure output and the microphone of a USB headset that is accessible as a Windows audio device. This requires two open-loop test operations executed in batch run. The playback and recording device are switched in both operations.

Since unknown delays are introduced by the D/A conversion and sample buffers, the *SYN* add-on is used to synchronize playback and capture using a unique synchronization signal or even the stimulus itself.

3.2 Hardware Setup

For general hardware requirements and necessary components refer to section *Requirements*.

The sketch below shows the typical hardware setup for a digital (active headset) with USB interface. In this example, the *KA3* with Laser and XLR Card is used, but the *Production Analyzer* or an external sound card may be used instead.



- Connect the analyzer to a free USB port of the PC using the USB cable provided by KLIPPEL (avoid hubs or front USB)
- Connect the headset to another USB port of the PC (avoid hubs or front USB)
- Connect the microphones of the test fixture to *IN3* and *IN4* of the *Laser Card*
- Connect OUT1 of the Laser Card to the BNC input of the mouth simulator; an adaptor is required in case an XLR Output is used instead (for KA3: make sure that the *Output* is set accordingly in *KA3 Signal Configuration* dialog – see section *Global Signal Routing (KA3)*)
- Optional: connect the ambient noise microphone to IN1 of the XLR Card (use an XLR-BNC adaptor for microphones with IEPE supply); Note that ambient noise detection is not applicable during microphone test

When placing the DUT on the test fixture, make sure that the microphone arm is placed in a defined position relative to the output of the artificial mouth.

3.3 Test Sequence

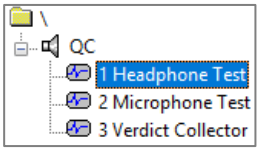
Template

The test template *Active Headset (USB)* is provided with this application note or your KLIPPEL software. Create a new test based on the template and open the test via *View* button in *QC Start Engineer* or open the database directly with *dB-Lab*.

***Note**: This template is not operable with QC Basic license and requires dB-Lab 210 (QC 6.1) or higher. A SYN license is required to run the test with default settings. Optionally, an EXD Bluetooth license is required for assisted Bluetooth pairing.*

Batch Run Object

The template does not contain a single QC operation, but a complete object that contains three operations:



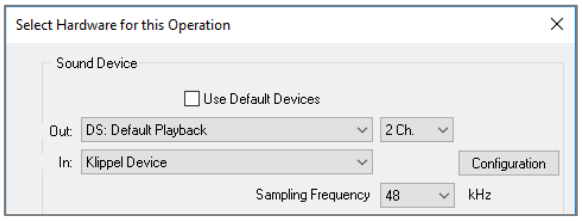
- 1 Headphone Test: acoustical test of headset playback
- 2 Microphone Test: acoustical test of headset microphone, stimulus provided by artificial mouth

3 Verdict Collector: this is a special operation dedicated to collecting and displaying the individual test verdicts of multiple QC operations and combining it to an overall verdict. The individual *Summary Windows* of the measurement operations are hidden by default.

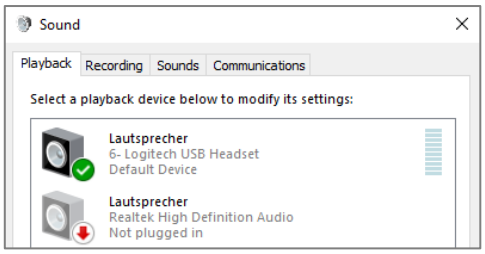
Sound Device Setup

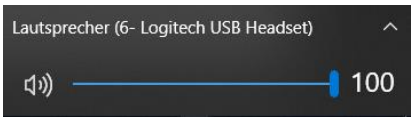
1 Headphone Test

Right click on operation *1 Headphone Test* and select *Properties...* to open the *Property Page*. In the tab *QC Settings* click *Configure Hardware* to access the sound device settings. In the template, the *Windows Default Playback* device is selected as output device. Alternatively, you can select your DUT directly. The input device should be set to *Klippel Device* for microphone signal input.



In case your device is not listed, make sure that it is actually available in the *Windows Sound* configuration. For *Default Playback* device setting, verify at least once that your device is selected accordingly in *Windows Sound Panel* or click the loudspeaker symbol in the task bar and select your device.





You may also use the *Enumerate Devices* button in the *QC Control Panel* to get an overview.

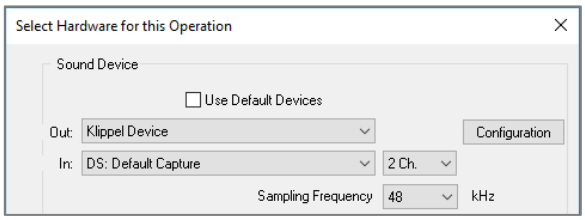
Audio device enumeration

Name	Playback	Capture	Default
Default Capture	F	T	
Default Playback	T	F	
Default Voice Capture	F	T	
Default Voice Playback	T	F	
FlexASIO	T	T	
JackRouter	T	T	
Lautsprecher (6- Logitech USB Headset)	T	F	Voice Playback
Mikrofon (6- Logitech USB Headset)	F	T	Voice Capture

Note: the advantage of using the Windows Default Device is that you can switch the DUT in EoL testing without changing QC Sound Device properties each time. However, make sure that system sounds are turned off. The External Devices task can be used to verify that the correct audio device is selected as default device (see next section).

2 Microphone Test

Also open the hardware configuration for the second operation. Now your device or *Default Capture* device must be selected as input device and *Klippel Device* is selected as the output for the sound source.

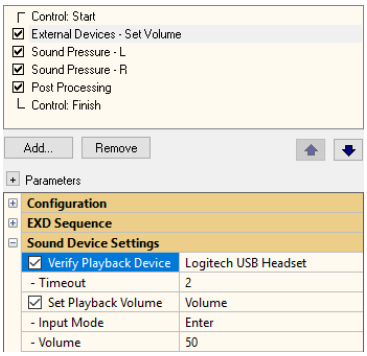


The information given for the playback device above also applies here.

3.4 Adjust Settings

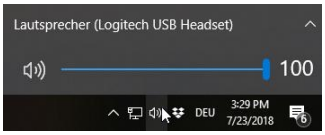
Headphone Test

Select operation 1 and log in using the green arrow icon in the task bar to access the test properties of this particular operation.



Sound Device Check and Volume (EXD)

First in the sequence is and *External Devices* (EXD) task with *Sound Device Handling* preset activated. You can enter the name of your sound device under test as shown in Windows Sound properties here to check that the correct device is connected and activated before testing. Otherwise the test will be blocked. Also enter the desired device playback volume here. The volume entered here corresponds to the volume shown in the task bar.



Stimulus Level (SPL)

Now select Sound Pressure task to define stimulus test level. For digital output audio devices, the *Stimulus Level* in the QC task properties is specified as a digital level in dBFS. Mind that the actual level setting of the headphone sound device (see above) is independent of the *Stimulus Level* setting.

Stimulus	
Start	20
Stop	20000
Time	1
Stimulus Level	-12

Note: Since the test level for digital devices may be difficult to define, the EQA module may be applied to achieve a defined target SPL by adjusting stimulus level automatically. Find more information in section Adjusting Target SPL. Alternatively, floating limits may be used to test frequency response independent of the total level.

Frequency Range

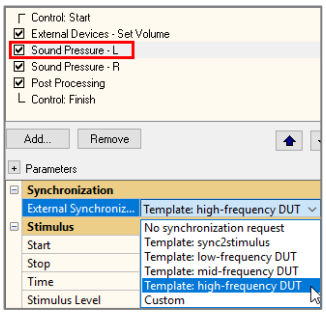
Adjust test bandwidth (*Start, Stop*) to the rated frequency range of the DUT in case limitations apply.

Ambient Noise

The information given in section *Passive Headphone* also applies here.

SYN Settings

The *External Synchronization* should be activated for both headphone and microphone test to ensure synchronous playback and analysis. This is already the case for the provided template.



In *Control:Start* task, the *Execution Mode - SYN: dynamic must* be selected. The individual measurement tasks may request synchronization. It is sufficient to place only one sync request for the first task. For a headset, the fastest template *high-frequency DUT* or *sync2stimulus* are suitable in most cases. For the latter case, the stimulus is directly used for synchronization, while other modes use a short noise signal before the main stimulus.

Microphone Test

Select operation 2 and log in to access the properties of the microphone test.

Sound Device Check and Volume (EXD)

The same information given above also applied to the capture device.

Voltage

The input voltage for driving the *G.R.A.S. 44AA* mouth simulator with built-in amplifier should not exceed 2 V. The EQA module may be used together with a reference microphone to find the corresponding excitation voltage for a defined target SPL.

Frequency Range

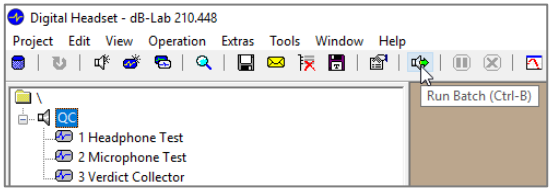
Careful setting of *Fmin* and *Fmax* for the microphone test is crucial as it depends on both the sound source and mic frequency range as well as the microphone position relative to the source. The *44AA* mouth simulator should not be operated below 100 Hz or 200 Hz and above 16 kHz or 6 kHz depending on effective level (please refer to the manufacturer specification). Depending on the DUT's microphone position, the source directivity might limit the upper frequency.

3.5 Run Test (Batch Run)

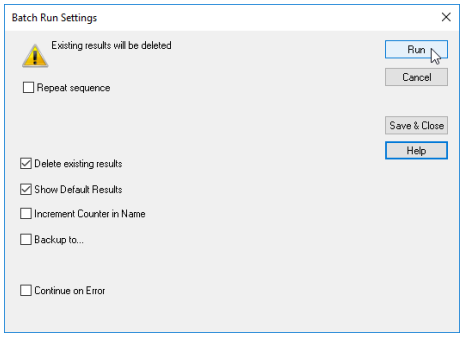
Single Operations

In order to verify settings and limit setup, it is recommended to run the individual operations separately during setup phase. This is done by loggin into the QC operations using the green arrow button in the task bar. The measurement can be started by clicking the pause button or using the *Start* button on the QC *Control Panel* (this window must be activated in the dB-Lab window list).

Full Batch Run



To execute the complete operation sequence and generate an overall test verdict, the *Batch Run* must be started by selecting the *QC* object and clicking the *Run Batch* icon in the task bar (Ctrl-B).The batch run options in the following dialog should be set as shown on the right.



Serial Number Handling

Since the normal *QC Control Panel* cannot be used for batch run, the standard serial number input field is not available. However, the *Verdict Collector* will handle any serial number provided by the source QC operations. It is possible to use automated serial number mode in operation *1 Headphone Test.* Alternstively, serial number import from text file is available.

3.6 Results

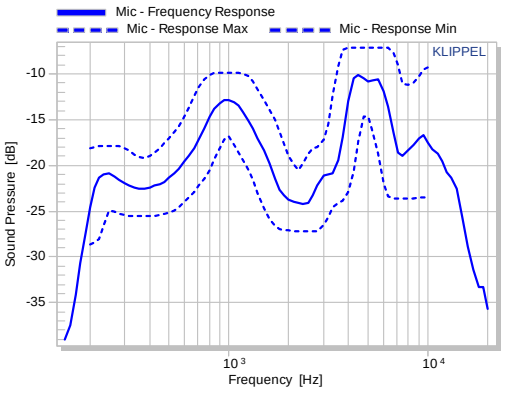
The acoustical test results for the headphone part are equivalent to the *Passive Headphone*. This section only addresses new results related to the microphone test.

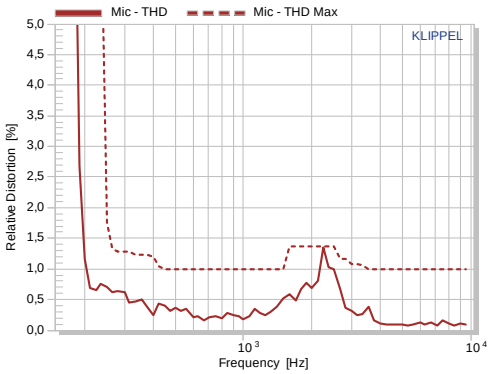
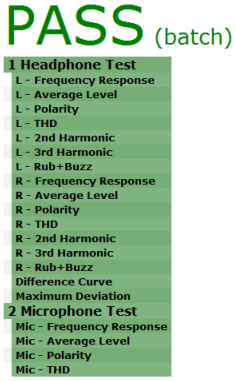
Frequency Response (Mic)

Since the input audio device of the microphone test is digital and the DUT microphone is not calibrated, the input data is only available as a digital level (dBFS).

The sound source may be equalized using the sweep Level Profile (and EQA module), but the headroom for adjustment is limited due to voltage and frequency range limits of the artificial mouth. Other sound sources may be used if more suitable for the DUT geometry or microphone specification

Ambient noise detection is not available since sound pressure calibration for all sensors must be available.



THD (Mic)	Total Harmonic Distortion can be measured in percent relative to the measured fundamental frequency response. However, the impact of sound source and microphone cannot be separated. Also, dips in the frequency response may cause significant peaks in the relative distortion. Still, using reasonable limits, irregular behavior of the DUT may be detected. 
Overall Verdict	The *QC Verdict Collector* operation gathers all results of the previous operation and generates a final overall verdict and a complete verdict list. 

3.7 Limit Calculation

Refer to section 2.6 Limit Calculation

Floating limits may be applied to the frequency response to ignore absolute level variation of active systems (see section *7.6 Frequency Response*: Level Normalization & Floating Limits).

4 Bluetooth Enabled Headphone with ANC

4.1 Overview

The approach for testing *Bluetooth* enabled devices is very similar to digital, wired devices. However, the wireless signal transmission introduces some additional challenges.

For detailed information related to testing devices with Bluetooth wireless technology, also refer to AN 76 QC Testing of Wireless Audio Devices. Only basic information is provided here.

Complementing the headphone response test, this application also includes a noise attenuation (ANC) test based on the transfer function between an external microphone and the test fixture microphone. Two symmetric external sound sources are used to provide the stimulus signal.

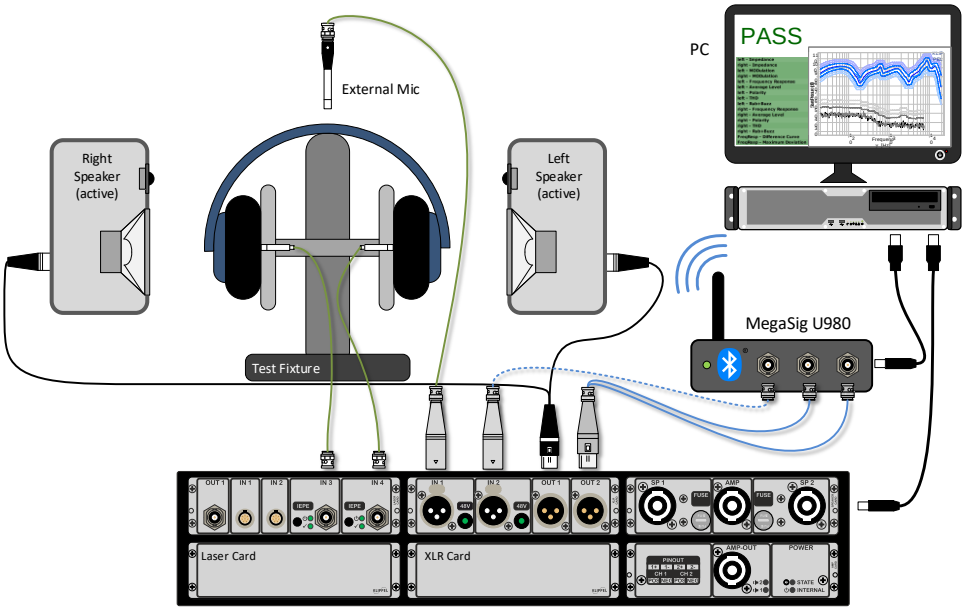
Note: This test approach provides only an attenuation estimate, but with sufficient relevance for relative QC testing. It is effective and fast since it involves no manual interaction like ANC on/off switching. However, an actual A-B comparison measured with the same microphone (test fixture) with ANC on/off is more accurate and can be set up, alternatively. Refer to "Insertion Method" below for more information.

A headset microphone test may be added (optional) using the same sound sources or an additional source such as the mouth simulator used in application *Digital Headset (USB)*.

4.2 Hardware Setup

For general hardware requirements and necessary components refer to section *Requirements*.

The sketch below shows the typical hardware setup for a *Bluetooth* enabled headphone test incl. ANC. In this example, active sound sources are used. Therefore, only a *KA3* with Laser and XLR Card is required. However, the *Production Analyzer* or an external sound card may be used instead.



Sound attenuation tests according to standards usually require a diffuse sound field. This scenario is not practical for QC applications. Therefore, a setup of two symmetrical direct sound sources (active full range speakers) is used to playback the ANC test signal (noise, wave signal). A single sound source on the symmetry axis might be used instead as well. Passive speakers are driven directly by the *Amplifier Card* of the *KA3* or an external power amplifier.

- Connect the analyzer to a USB port of the PC using the USB cable provided by KLIPPEL (avoid hubs or front USB)
- Connect the Bluetooth interface to a free USB port of the PC and make sure that the drivers are installed
- Connect the output(s) of the analyzer (e.g. *XLR Card OUT*) to the *Speaker* input(s) of the *Bluetooth* interface using the BNC cables and optional XLR-BNC adaptors
- Opt. for headsets: connect the *Mic* signal output of the *Bluetooth* interface to the analyzer input (e.g. *XLR Card IN2*) using a BNC cable and optional XLR-BNC adaptor
- Connect the microphones of the test fixture to *IN3* and *IN4* of the *Laser Card*
- Connect the external microphone to IN1 of the XLR Card (use an XLR-BNC adaptor for microphones with IEPE supply)
- Connect OUT1/2 of the XLR Card to the input(s) of the active speaker(s) and ensure that the speakers are powered and switched on

Since up to four output channels are required for stereo headphone testing and symmetric ANC excitation, either use y-adaptors to split the signals or an XLR-OUT Multiplexer (2x4 configuration) as output channels are limited.

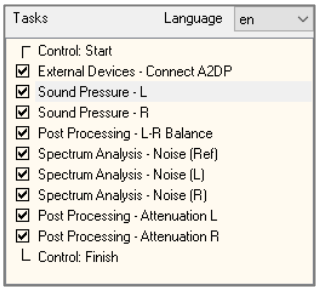
4.3 Test Sequence

Template

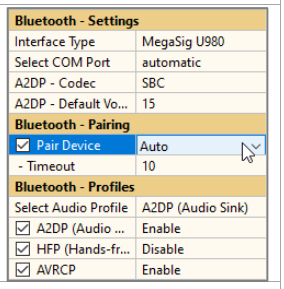
The following test templates are provided with the QC software for this application

- *Bluetooth Headphone (MegaSig)*
- *Bluetooth Headphone with ANC (MegaSig).*

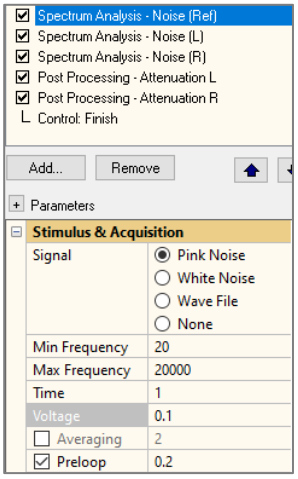
The latter will be addressed here. Create a new test based on the template and open it using

	Start button in *QC Start Engineer*. ***Note**: This template requires dB-Lab QC 6.4 (210.610) or higher and a SYN license to run the test with default settings. The ANC test is not operable in QC in R&D framework without modification (sequence must be split).*
Task Sequence	 The template for Bluetooth headphone and attenuation testing comprises a comprehensive sequence of configuration, test and post-processing tasks since multiple signal paths shall be tested. The **Connect A2DP** step takes care of the Bluetooth device pairing and audio profile configuration. In the following **Sound Pressure - L & R** steps, a sine sweep is played through both channels of the Bluetooth audio link simultaneously and both left and rigth ear piece responses will be tested using the mics of the headphone test fixture. **L-R Balance** then calculates the difference between left and right channel's frequency responses. In the following **Spectrum Analysis** steps, pink noise is played through the active speakers and the response for all three microphones is measured. The appended post processing steps **Attenuation L & R** calculate the effective total headphone attenuation (passive & ANC) from the transfer function between external and occluded microphones.

4.4 Adjust Settings

Connect A2DP	 With default settings, the Bluetooth interface is detected automatically and any Bluetooth device with activated pairing mode will be connected. It is recommended to set **Select COM Port – manual** for optimal timing. Also, address-based device pairing (**Pair Device - Address**) with operator prompt input is beneficial to avoid device confusion in case there is no RF shielding of the test station. By default, A2DP with **SBC** codec is selected, but you may switch to other codecs if required.
Sound Pressure L/R	The information given in *Headphone Test* and *SYN Settings* (*Digital Headset (USB)*) also applies here. **Routing** Adjust input routing for both *Sound Pressure* tasks if necessary. Only output *Out1* is used for playback assuming parallel connection (y-adaptor) to both input channels of the Bluetooth converter. *If an XLR—Out Multiplexer is used instead, adjust routing settings accordingly and select the right channel through Digital Output.* **Frequency Range** Since *Signal Sharing* feature is used, the first task records both microphone channels while the second one just processes the recorded response. Therefore, stimulus settings are only available in *Sound Pressure – L.* *Using a multiplexer, botch channels may be tested individually, if required. In this case delete Source Task parameter in Sound Pressure – R.* Adjust test bandwidth (*Start, Stop*) to the rated frequency range of the DUT in case limitations apply. It can be beneficial to sweep downwards (F_{start} > F_{stop}) to reduce phase error at high frequencies due to sample clock jitter and drifts. **Stimulus Voltage** *Voltage* parameter specifies the RMS voltage of the chirp signal fed to the analog input of the *Bluetooth* interface. It is independent of the actual playback level of the DUT that is controlled by the *Connect A2DP* step. Also refer to the information given in section *Passive Headphone.* *The maximum sinusoidal RMS input voltage for the MegaSig U980 should not exceed 0.56 V to avoid clipping.* **Ambient Noise**

	Ambient noise detection using the external microphone is activated by default. The information given in section *Passive Headphone* also applies here. For optimal overall test time, *PNI* add-on is recommended for immediate auto repeat and merge of the disturbed measurement in case noise corruption is detected.
Spectrum Analysis (Noise Attenuation)	**Signal** The *SAN* task provides an internal noise generator (pink nosie used by default) and also allows importing arbitrary stimuli (e.g. simulated programme signal) from wave files. A *Preloop* is recommedned in order to make sure that the ANC algorithm is in a steady state when the measurement starts. **Min & Max Frequency** The default bandwidth setting for the stimulus is set to full audio range, but may be limited according to specification. However, limit check range for attenuation may be adjusted separately. **Voltage** The test *Voltage* controls the input voltage of the active speaker and therefore the effective output SPL depends on the sensitivity and gain setting. The *Level* and *Input Spectrum* reading of *Noise (Ref)* step can be used to adjust target SPL. The level should provide sufficient SNR in the frequency range of interest for the internal microphones when the DUT is mounted and ANC is activated. Refer to *Signal to Noise Ratio Considerations* for more infromation. *Note: Since Signal Sharing feature is not available in SAN yet, make sure that the settings are identical for all three SAN tasks (except for routing).* **Routing** In the template, the stimulus signal is always played output *Out2*. To address left and right source independently, switch global output routing *Control:Start* task to *controlled by task*. *Note: Signal Data Sharing feature is not yet available for SAN task. Therefore, all three microphone responses are measured sequentially, currently.*

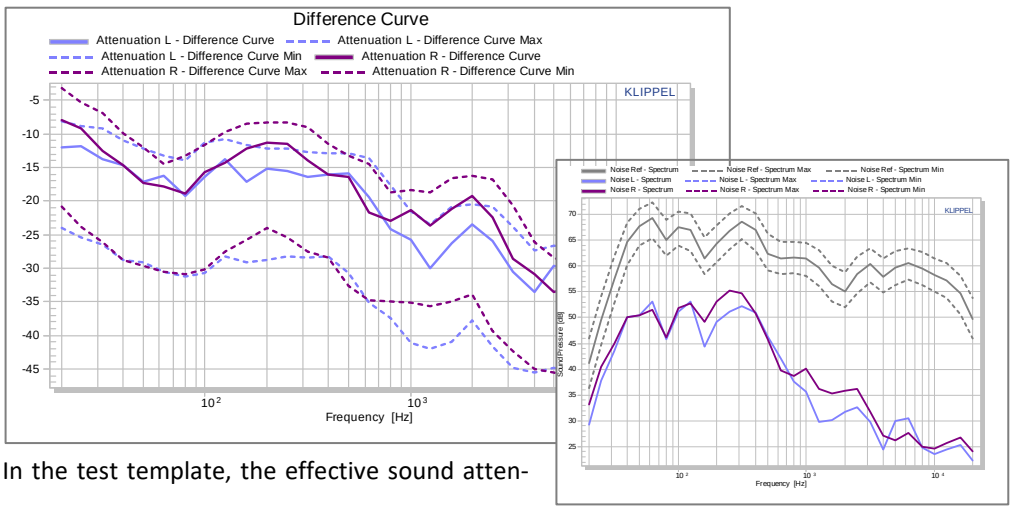


4.5 Run Test

	The whole sequence basically runs automatically if everything is set up correctly. Make sure to switch on the DUT and activate pairing mode before starting the test using *Start* button in *Control Panel*.

4.6 Results

The acoustical test results of the headphone response are basically equivalent to the *Passive Headphone*. The following section only addresses additional results related to the sound attenuation test.

Sound Attenuation	**Transfer Function Method**  In the test template, the effective sound atten-

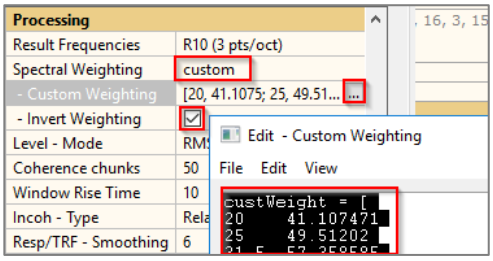
uation (figure above) is measured as the transfer function (level difference) between the SPL spectra of the external reference microphone (right figure, grey curve) and the test fixture microphones in the left and right ear plate (right figure, colored curves) while a noise signal is played back by the external sound source. The result should be negative for all excited frequencies (ANC at low frequencies, passive attenuation at high frequencies). The signal to noise ratio should be considered for setting a reasonable test level (see *7.3 Signal to Noise Ratio Considerations*).

The transfer function method is very convenient but it has some limitations that should be noted:

- Sound field at external microphone position is exactly not identical to sound field at ear pieces (source & mic directivity, room acoustics, …)
- Attenuation curve includes differences between frequency response of the external and internal microphone as well as calibration errors
- directivity, location and mic difference – however, good quick check with manual interaction (remove headphone, activate ANC)

However, those effects are tolerated since the test limits are derived from approved reference units measured under the same conditions.

Insertion Method



Alternatively, the insertion method may be used. In this case, the SPL responses of the test fixture microphones are measured twice, one time without DUT (or ANC deactivated) and one time with DUT mounted (or ANC activated).

For testing the complete insertion attenuation, the reference response of the bare test fixture without DUT can be assumed constant and only needs to be measured once. The difference calculation not necessary in this case, the reference curve can just be measured once and imported as a custom weighting curve as shown in the screenshot.

4.7 Limit Calculation

Refer to section 2.6 Limit Calculation

Floating limits may be applied to the frequency response to ignore absolute level variation (see section *7.6 Frequency Response*: Level Normalization & Floating Limits).

For the sound attenuation (*Difference L & R*) calculated by the *Post-Processing* define an upper limit to test the minimal required noise damping. Relative limits based on approved reference units are recommended instead of absolute limits to account for the specific signal and test setup. A lower limit is normally not required and may be set with high tolerance. Restrict the frequency range of the limit to the range of interest and only test frequencies that are within the bandwidth of the active speakers.

5 Preparation

5.1 Adjusting Test Fixture

Adjust Width and Headband Holder	Place the DUT on the test fixture and follow the instructions in *G.R.A.S. 45CC Instruction Manual* sections *Mounting the Ear plate Assemblies, Adjusting the Headband Holder Height and Adjusting the Horizontal Position* in order to adjust the fixture optimally. Make sure that the headband is set to a defined position and that the ear pieces are well-centered on the ear plate during this process. Also ensure that the ear plate distance is sufficient wide to avoid leakage due to lacking pressure of the ear cushions.	
Adjust Positioning Guides	The positioning guides of the 45CC make sure that the ear pieces are always well-centered on the ear plate (over the microphones) in order to ensure reproducible results even at high frequencies. Follow the instructions in *G.R.A.S. 45CC Instruction Manual* section *Adjusting the Positioning Guides*	

5.2 Preparing Custom Cables and Connectors

For testing passive headphones and headsets, it is required to provide custom adaptors and cables in order to connect the DUT to the analyzer as well as the amplifier correctly.

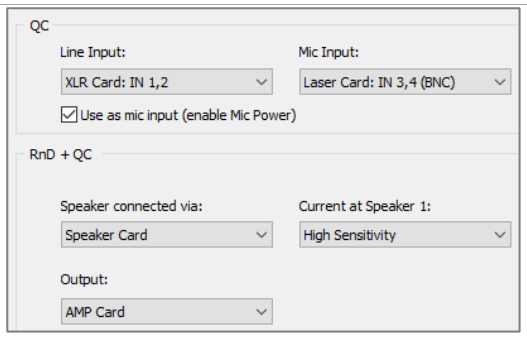
Connecting Passive Stereo Headphones	Passive stereo headphones usually have a common ground for both, left and right channel. This must be considered for the hardware setup and wiring. Additionally, the speakON outputs of the analyzer hardware need be adapted correctly to the input connector of the device under test (typically 3-pole jack). For more information and a wiring diagram, please refer to appendix section *Custom Cables for Passive Headphones*.
Headset Microphone Adaptor	Typical microphones in passive multi-media headsets require a supply voltage in order to provide an output signal. Please refer to section *Power Supply Adaptor for Headset Electret Microphone* in the appendix for more information.

5.3 Global Signal Routing (KA3)

Skip this section in case you are using Production Analyzer or a 3rd party sound card for testing.

For KA3 hardware it is required to set the global signal configuration depending on the general test setup and KA3 card configuration. In the *Signal Configuration* dialog, the actual hardware channels are assigned to the routings available in the QC operation.

- Start *dB-Lab QC* or the instance of *dB-Lab* you would like to use for testing
- Open *KA3 Signal Configuration* dialog via menu *Extras – KA3 – Signal Configuration*



- Assign the *Mic Input* to *Laser Card* (test fixture microphones)
- Assign *Line Input* to *XLR Card* and enable mic power only in case you want to
  - use an ambient noise microphone
  - test a headset microphone
  - measure noise attenuation with an external microphone
- *Output*
  - In case you are using an external amplifier, an active sound source or a Bluetooth converter with analog input (MegaSig U980), select *XLR Card*
  - In case you are using the *Amplifier Card* of the KA3, select *AMP Card*
  - If you want to measure a headset with an active artificial mouth, select *Laser Card*
- For passive headphones: the optimal current sensitivity setting for the speaker channels depends on the nominal impedance of the DUT. *High Sensitivity* is recommended for most headphone to provide optimal current SNR.

Find more information in *Hardware Manual* section *KA3 Signal Configuration*.

5.4 Amplifier Calibration

Skip this step for digital or wireless headphones.

The amplifier (either external or internal) must be calibrated once after setup in order to use the Speaker channels in the QC operation.

- Access amplifier calibration via *QC Start – Calibrate – Klippel Analyzer* or *dB-Lab* menu *Extras – KA3 – Calibration for QC Operations*
- Click the *Calibrate Amp* button in the *Control Panel* to start calibration
- If the amplifier connection is correct, only *Out 1 to Speaker 1/2* should be marked green

- If this is not the case, please refer to section *Connecting Passive Stereo Headphones*

Find more information in QC User Manual section Amplifier Gain Calibration.

5.5 Microphone Calibration

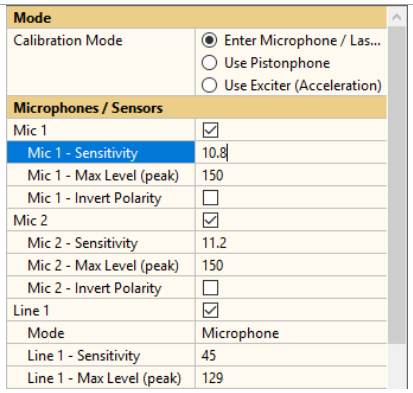
For all static test microphones (test fixture and external mics for ambient noise or attenuation tests), calibration data must be available before use.

- Access microphone calibration via *QC Start – Calibrate – Klippel Analyzer* or *dB-Lab* menu *Extras – KA3 – Calibration for QC Operations*
- In the Property Page – Tasks, select Microphone / Sensor Calibration to set the calibration mode or enter calibration sheet data

Find more information in QC User Manual section Microphone & Sensor Calibration.

Using Calibration Sheet Data

- If you just want to start with manufacturer calibration data, select *Calibration Mode – Enter Microphone Sensitivity* and enter *sensitivity* and *max. SPL* from the calibration sheet provided by the manufacturer or KLIPPEL



- Click *Calibrate Mic* button in the *Control Panel* to store the entered data

Using Sound Calibrator or Pistonphone

- Select *Use Pistonphone* in case you want to measure sensitivity with pistonphone or sound calibrator
- Enter the *Test Frequency* and *Test Level* according to your calibrator device
- Follow the instructions in G.R.A.S. 45CC manual section Calibration to disassembly the microphones from the test fixture
- Select the input channels you want to calibrate one by one, enter max SPL from spec sheet and click *Calibrate Mic* to calibrate the selected channel.

5.6 Install Bluetooth Interface Drivers

The *MegaSig U980* interface requires USB drivers to be controlled through the USB interface. You can find the driver setup in the setup files of the QC software. Please refer *to EXD Manual* section *Setting up the Hardware* for detailed instructions.

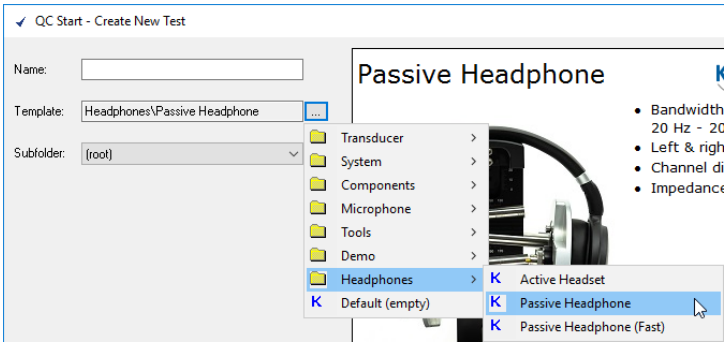
The drivers and additional software for manual operation is available from the manufacturer website.

5.7 Test Templates

Several QC test template for passive headphones are provided together with this application note or delivered with the KLIPPEL software.

QC Test Template

From QC Version 6.1, dedicated headphone test templates are included in the software distribution. You may access them via *QC Start Engineer – Test – New...* . Navigate to template category “Headphones”.



Find more information in the QC User Manual section Organizing Projects using QC-Start.

R&D Framework

In case the *QC Start* software (part of QC framework) is not available, you may directly work on the provided template databases with *dB-Lab*. You may create your own object and operation templates from them.

Alternatively, KLIPPEL operation or object templates for headphones may be used, if available in your software distribution.

Find more information in the dB-Lab User Manual section Creating and Managing Templates.

6 Requirements

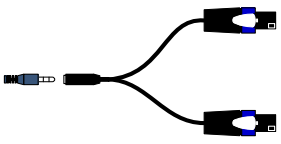
6.1 Example Set

	The recommended hard- and software components listed in the following paragraph are based on Example Set for Headphone Quality Control.

6.2 Hardware

Test Fixture	This application note utilizes the G.R.A.S. 45CC headset test fixture dedicated to quality control. Different sets are available with and without ear simulator or artificial mouth.
	This application note focuses on the following sets distributed by KLIPPEL
	• **G.R.A.S. 45CC-2** Set (Item No. 2400-079)
	  ○ 45CC test fixture
	  ○ 2x 69CC-2 IEPE Microphone Set
	• **G.R.A.S. 45CC-6** Set (Item No. 2400-080):
	  ○ 45CC test fixture
	  ○ 2x 69CC-2 IEPE Microphone Set
	  ○ 44AA Mouth Simulator
	• Optional extension with RA0039 (IEC 60318-1) ear simulator → 45CC-4/8
	Note: See specification A14 – Artificial Ears and Mouths for more information. The information provided in this document can also be applied with other test fixtures.
	For price sensitive applications, similar custom-made test fixtures can be used.
		
		G.R.A.S. 45CC-6 Set

Klippel Analyzer	• **KA3 – KLIPPEL Analyzer 3** (Item No. 2000-3xx) equipped with
	  ○ Laser Card (IEPE mic input)
	  ○ Speaker Card (for passive DUTs)
	  ○ Amplifier Card (for passive DUTs)
	  ○ XLR Card (output for external amplifier or input for headset microphone)
	Or
	• **PA – Production Analyzer** (Item No. 4000-100)
	Note: in case only acoustical parameters are tested, also 3rd party sound cards may be used. QC Stand-alone *software is required in this case.*
	A KLIPPEL USB license dongle is required to operate the software. Licenses may also be issued for KA3.
		
		KLIPPEL Analyzer 3 (ALSX)

PC	A Windows PC is required to operate the KLIPPEL software. See separate document *KLIPPEL PC Requirements* for further information.	
Components for Passive Headphone	The following equipment is required for testing passive devices: • External amplifier (for use with PA) – e.g. *Lake People F388 S* (Item No. 2700-011) • Custom DUT connection cable (e.g. 2x *speakON* to 3.5 mm connector) • Amplifier cable (mono, bridged) • Headset microphone supply adaptor See *Preparing Custom Cables and Connectors* for more information.	 *Stereo phone connector to mono speakON adaptor cable*

Additional Microphone	In order to detect ambient noise corruption or measure noise attenuation by transfer function method, an additional microphone is required. A cost-efficient choice is the **MIC 40PP** by G.R.A.S (Item No. 2400-330) with • XLR-BNC adaptor for use with KA3 XLR Card (Item No. 2300-102) • IEPE Supply IV11-S for use with PA Line input (Item No. 2400-301) For use with KA3 XLR Card, also a phantom powered microphone, such as *MIC255 48V* (Item No. 2400-311) can be used.	 *Mic 40PP*
Sound Sources	For testing passive or active (ANC) sound attenuation one or better two symmetric broad band sound sources are required. Also, for EoL testing of the headset microphone response, a professional speaker is more suitable than an artificial mouth. Active speakers are connected to the line outputs of the analyzer, while passive speakers can be operated via an external amplifier or *KA3 Amplifier Card*. KLIPPEL distributes *Genelec* professional speakers. The compact and price-efficient model **Genelec 8010A** (Item No. 2800-500) is suitable for most EoL applications. *Please refer to specification A15 – Sound Source.*	 *Genelec 8010*
Bluetooth Transmitter	Testing wireless devices with *Bluetooth* technology requires a dedicated converter in order to send stimulus signals to the DUT or receive response signals from the integrated microphone(s). The recommended interface device for this application is the **MegaSig U980** (Art. Nr. 2800-406) distributed by KLIPPEL. This professional, converter with analog stereo inputs and one output is directly connected to the analyzer hardware. Device pairing and codec control is realized by the KLIPPEL software via the provided USB control interface. The hardware set includes adaptors and cables. *Find more information in AN76 Quality Control of Wireless Devices and specification A6 – Accessories.*	 *MegaSig U980*
Output Switcher	Testing stereo headphones with integrated microphones for telephony or ANC often requires more than two signal outputs in order to provide test signals to the inputs of the Bluetooth converter and the reference sound sources. An **XLR-Out Multiplexer** (Item No. 2800-103) is suitable for automated switching between those devices in the test sequence. *Refer to specification A8 Multiplexer for more information.*	 *KLIPPEL MUX*

6.3 Software

KLIPPEL QC Software	• **QC Standard** software (Item No. 4002-010) – includes test tasks: *SPL, IMP, SAN, PP, …* Alternatives: • *QC Basic* (Item No. 4003-002) for basic stereo headphone tests – only includes test task *SPL-IMP* • *QC Stand-alone Software* (Item No. 4004-500) - plain acoustical tests using 3rd party sound cards (includes the same test tasks as QC Standard, except for *IMP*)
QC in R&D Framework	• dB-Lab 210 • QC SPL – Sound Pressure Task (Item No. 4000-263) • QC IMP – Impedance Task (Item No. 4000-262) – only for passive DUTs • QC SAN – Spectrum Analysis (Item No. 4000-267) - attenuation and mic test with noise or

	custom signals General restrictions apply compared to QC Standard (see *QC User Manual* section *QC Software in the KLIPPEL R&D Framework*).
Optional Add-On Modules	• QC SYN – External Synchronization (for digital or wireless DUTs; Item No. 1001-107) • QC PNI – Production Noise Immunity (advanced ambient noise handling; Item No. 1001-107) • QC EQA – Equalization & Alignment (control voltage or SPL; Item No. 4000-245) • QC EXD Bluetooth – External Devices (Bluetooth pairing and profile control; Item No. 4000-251) – QC version > 6.4 required foe *MegaSig U980* control

6.4 Test Environment

Headphone Test	Optimal sensitivity for rub & buzz testing is provided in a silent test environment providing a low acoustical background noise floor. However, ambient noise corruption in a production environment can be detected (*QC Standard*) and handled (*PNI* add-on) reliably using an additional ambient noise microphone. For production tests, additional noise attenuation (test box) is still recommended, especially for open or semi-open headphones with low noise attenuation.
Headset or ANC Test	In case passive or active sound attenuation or a headset microphone shall be tested, an external sound source is required to provide defined excitation. Any additional noise disturbance may interfere with the measurement. Therefore, a silent or acoustically shielded test environment is highly recommended.

7 Further Topics

7.1 Applying Frequency Response Correction Curves

In order to simulate standard measurement conditions (e.g. complete ear simulator response at *DRP*, free or diffuse-field correction etc.) or for microphone frequency response correction, the measured frequency response may be adjusted using imported correction curves.

In *Sound Pressure* task, correction curves can be imported using the parameter *Response-EQU*.

Find more information in QC Manual section Response Equalization or Application Note 62.

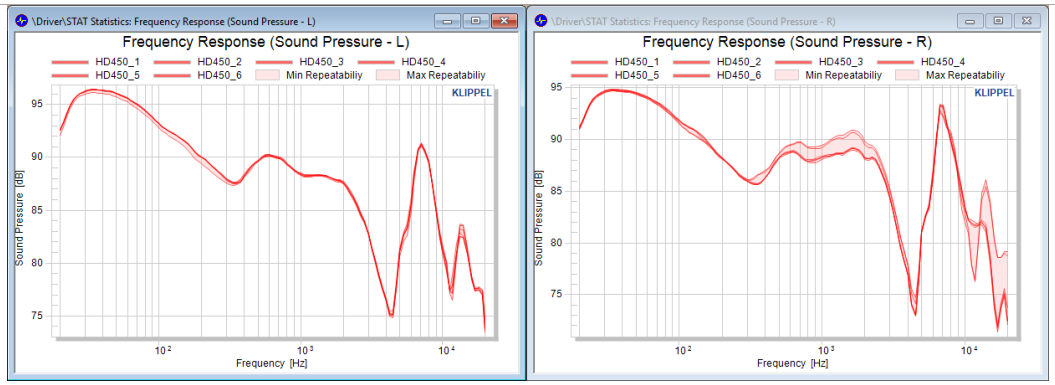
7.2 Evaluating Repeatability

Repeatable results are crucial for a QC test.

Sealing and Positioning

For headphones, positioning on the test fixture (affects low frequency response) and leakage (affects mid and high frequency response) are the most common sources of variation. The G.R.A.S. 45CC test fixture provides positioning guides and a plain ear plate without artificial outer ears to reduce those effects. Still, repeatability should be evaluated after finishing the test setup.

This can be done by mounting and testing one device multiple times and comparing the frequency responses. To overlay multiple responses, activate *Limit Calculation Mode*. Alternatively, the *Statistics (STAT)* module may be used for this purpose. It easily visualizes the response data taken from log databases and derived statistical information (mean, standard deviation …).



The screenshot above was generated with the *STAT* module. It displays six frequency responses for left and right ear channel. Repeatability for the left ear is good while the right ear shows variation at mid and high frequencies related to positioning problems.

Noise Floor and Ambient Noise

Other sources of variation can be related to a low signal-to-noise ratio (high noise floor) or ambient noise impact. Especially impulsive disturbances cause significant random variation in most acoustical parameters, but mainly in distortion and Rub&Buzz results. This disturbance can be detected and handled reliably using ambient noise detection or PNI feature. Refer to *QC Manual* section *How to Cope with Ambient Noise?* for more information.

General signal to noise ratio considerations are discussed in the next section.

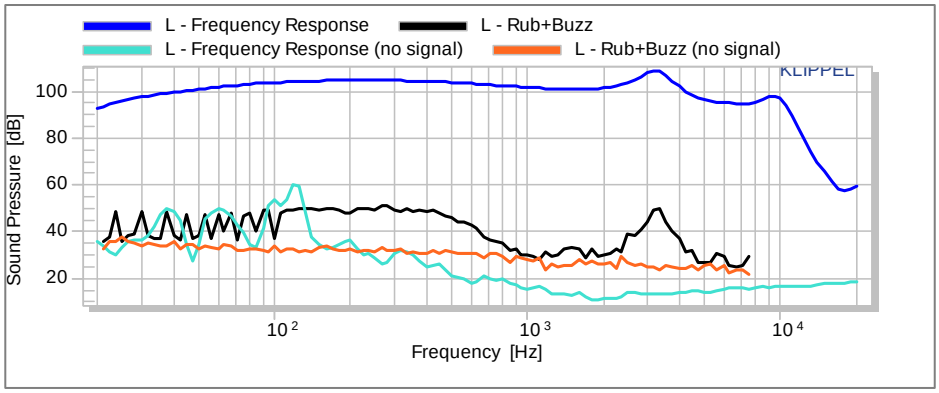
7.3 Signal to Noise Ratio Considerations

The signal-to-noise ratio (SNR) is defined by both the noise floor and the test level. It should be evaluated as part of the test setup process to ensure reproducible and meaningful results. Since the test level can only be increased with limitations and acoustical effects may reduce SPL in narrow frequency bands, it is mainly a noise floor consideration.

The noise floor of the acoustical test for both headphone and microphone is defined by

- electrical noise (active DUT electronics, amplifier, microphone, analyzer preamps, ...)
- acoustical noise (fans, AC, production noise, ...)
- signal processing artifacts (e.g. noise canceling algorithms)

In order to measure the total noise floor, just perform a normal measurement with DUT mounted, but set the stimulus voltage/level to a very small value (e.g. 1e-6 V or -100 dB). Now the results can be compared to the responses of a normal test (with excitation signal) as shown below.



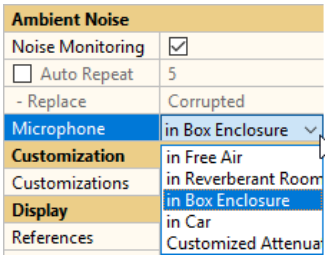
For the *Frequency Response*, all tested frequencies should have an SNR of at least 30 dB.

- increase test level, if possible
- apply stimulus shaping to emphasize frequencies with low output (see *7.5*)
- deactivate sources of ambient noise
- use a more sensitive microphone
- use relative limits with floor (e.g. for THD)

The difference in the *Rub&Buzz* response indicates whether there is systematic higher-order distortion or noise caused by the DUT above the noise floor or not. In the example above, the DUT domi-

nates the distortion and noise at all (excited) frequencies.

7.4 Measurement of Ambient Noise Attenuation



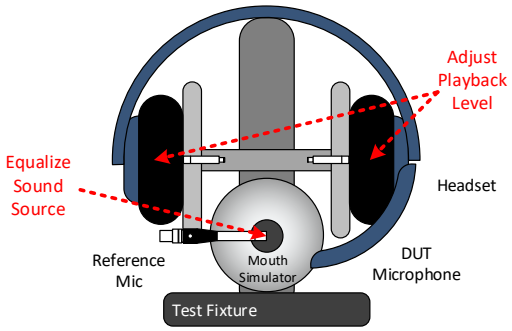
The ambient noise detection feature (QC Standard) and the *PNI* add-on rely on an external microphone to detect and handle external noise disturbances. For optimal performance, the noise attenuation between the external and the test microphone (e.g. test chamber or headphone ear piece) must be known. Several presets are available and for closed headphones, the standard setting *in Box Enclosure* may be a good first choice.

However, entering the exact passive attenuation of the headphone on the test fixture over frequency (*Custom Attenuation*) is preferable for optimal performance. Refer to *QC Manual* sections *How to Cope with Ambient Noise?* and *How to Measure Box Attenuation?* for more information.

7.5 Adjusting Target SPL and Sound Source Equalization

There are different scenarios where it is necessary to adjust playback level or frequency response to a certain target value or curve, such as

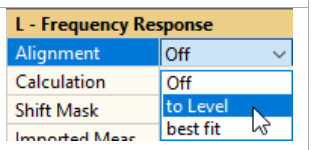
- Controlling playback test level (e.g. 94 dB at 1 kHz),
- Sound source (mouth simulator) equalization for microphone test or
- Adjusting test level of digital devices with no analog input.



The optional *Equalization & Alignment (EQA)* task meets those requirements.

It adjusts stimulus voltage/level and *Level Profile* (vs. frequency) in order to meet the target single tone or frequency response automatically. Also assisted manual adjustment is supported (e.g. for manual volume control). The resulting setting can be imported seamlessly into the measurement tasks in the test sequence. The alignment step can be part of the test sequence or an independent off-line operation. See *EQA User Manual* for more information.

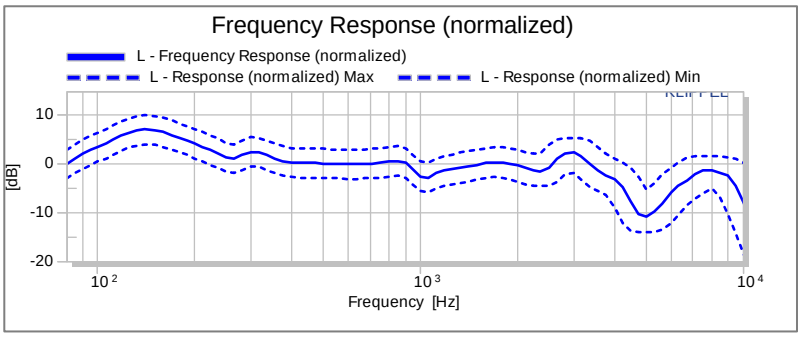
7.6 Frequency Response: Level Normalization & Floating Limits



For digital headphones with no analog input, it is more difficult to ensure that the playback level of the device is always identical for every tested unit. In order to test the frequency response neglecting the influence of the playback level, dedicated limit modes are available in *Limit Calculation Mode.* Using the mode *"to Level*", the limit curves are shifted by the change of average level relative to the reference measurement(s).

Processing	
Windowing of IR	Off
Result Frequencies	R40 (12 pts/oct)
Response - Smoothi	6
Response - EQU	
Response - Normalize	Average Level

The response normalization mode "Average level" fits well to this limit mode and results in a normalized view as shown below. Find more information in *QC User Manual*.

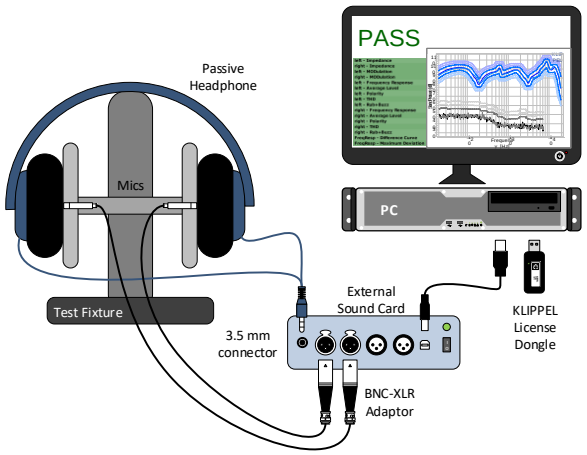


7.7 Basic Acoustical Test Using Sound Card

For plain acoustical tests, a KLIPPEL analyzer is not necessarily required. The *QC Stand-alone Software* version may be used instead together with a 3rd party audio interface (e.g. external USB sound card).

The sketch below shows the test setup for a passive headphone. The pre-polarized microphones as part the test fixture may be adapted to 48 V supply using a dedicated BNC (male) – XLR (male) adaptor.

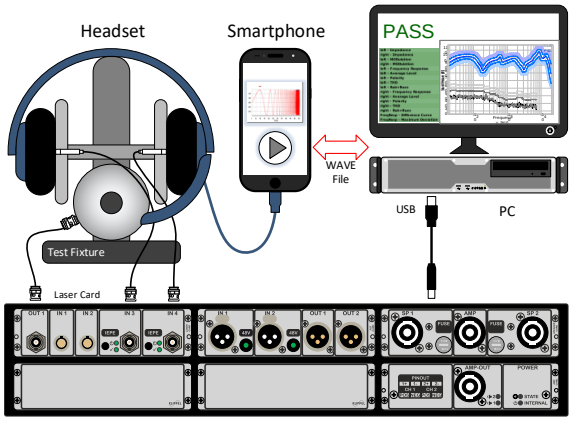
For more information, refer to *QC User Manual* section *Setup with Audio Interface (QC Stand-alone Software).*



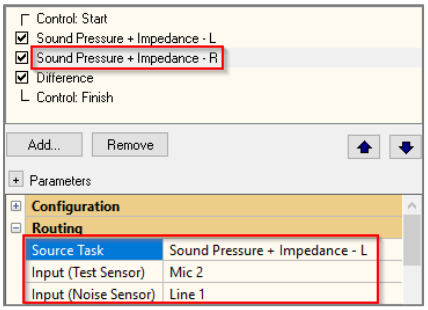
7.8 Open Loop Tests (Asynchronous Playback)

In some cases, it is not possible to connect digital headphones or headsets directly to the host PC (open loop setup).

The SYN module allows exporting the synchronization signal and test stimulus to a WAVE file that may be played back by an independent device (e.g. smartphone). The test waits until the synchronization signal is played back through the DUT. Alternatively, response files may be imported to the QC software, e.g. for testing the headset microphone in an open loop setup.



7.9 Test Speed Optimization: Signal Data Sharing



In a stereo test sequence, up to four individual measurements are performed (sound pressure and impedance tested for left and right channel). This may be accelerated by using the same stimulus for sound pressure and impedance test (SPL+IMP Task) while still testing every headphone channel individually. From QC version 6.1, up to 8 channels can be recorded simultaneously using the KA3 hardware. This allows measuring both channels with just one test signal played back on both channels simultaneously. Since most *QC Tasks* do not support this number of channels, input signal data sharing feature is provided, where the *Task* defines the test signal and records all requested channels and distributes the recorded signals to other receiving tasks.

The screenshot shows the setting for the *Passive Headphone (Fast)* test template. The first task acts as the signal source for the second task that only defines the requested input routing. Make sure that the output routing (global or source task) ensures signal playback on both left and right channel. For more information see *QC User Manual*.

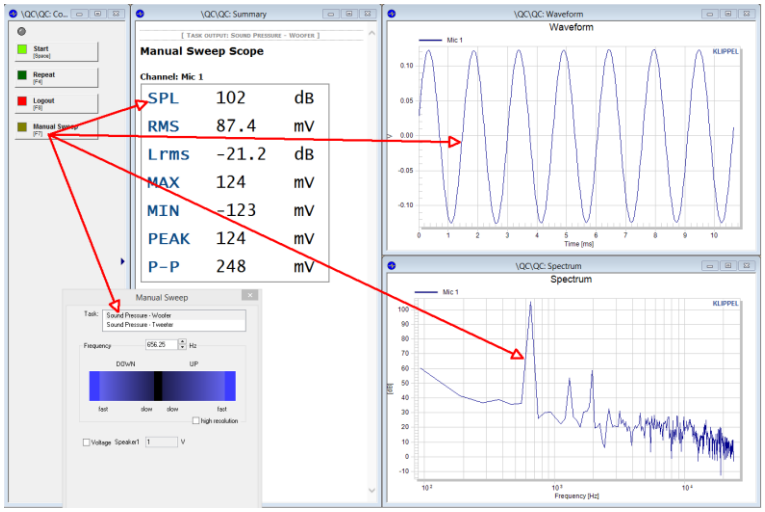
The simultaneous measurement also implies certain drawbacks that should be considered. Potential crosstalk might affect the results of the individual channels. Also, wrong wiring (swapped left and right channel signal line) cannot be detected.

7.10 Manual Sweep Diagnostics

Especially for digital or wireless devices, the signal chain from the signal source to the microphone inputs may be quite complex. During setup phase, a live scope is a helpful tool to check the signal outputs and inputs as well as SPL at certain frequencies.

The *Manual Sweep* feature provides an interactive sine tone generator and input signal scope including spectrum, waveform (total SPL and *Rub&Buzz*) and single value characteristics. The feature can be used if any sweep-based measurement task is used in the test sequence.

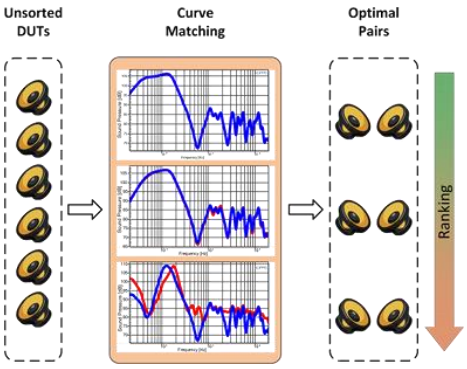
The optional *Manual Sweep Controller* allows controlling frequency and level intuitively. In addition, the sound pressure signal of the headphone mounted on the test fixture may be monitored in parallel easily via the PC sound card. For more information, refer to *QC User Manual* sections *Manual Sweep* and *Live-Monitoring of microphone signal.*



Live view of manual sweep

Manual Sweep Controller

7.11 Matching Optimal Transducer Pairs Before Assembly



For high-end and audiometry headphones it is desirable to ensure optimal spectral balance between left and right channel. To ensure this, the channel difference of the frequency response is tested in the provided headphone test templates.

However, it is much more efficient and economical to match optimal pairs before assembly. The *Match Speaker Tool (MSP)* is dedicated to matching optimal pairs from a pool of KLIPPEL QC driver test log data. Different pairing algorithms are available in order to find the best matching pairs or the maximal number of pairs. Weighting functions and deviation limits provide a customizable solution to yield the optimal audio quality from your production.

8 References

8.1 Manuals

- G.R.A.S. 45CC Instruction Manual
- QC User Manual
- SYN User Manual
- EQA User Manual
- EXD User Manual
- PNI User Manual
- SAN User Manual
- QC Feature Library Manual

	• dB-Lab User Manual • Hardware Manual • Multiplexer User Manual

8.2 Specifications	Software
	• C3 - QC Set
	• S21 - QC PNI – Production Noise Immunity
	• S31 - QC EXD – External Devices
	• S32 - QC SYN – External Synchronization
	• S33 - QC EQA – Equalization & Alignment
	• S36 - QC Feature Libraries
	• S48 - Statistics
	• S55 – QC PP – Post Processing
	• S65 - QC SAN - Spectrum Analysis
	Hardware
	• A4 - Microphones
	• A6 – Accessories for the KLIPPEL Analyzer System
	• A8 - Multiplexer
	• A14 - Artificial Ears & Mouths
	• A15 – Sound Sources
	• H3 - Klippel Analyzer 3
	  ○ H6 – Amplifier Card
	  ○ H7 – Laser card
	  ○ H8 – Speaker Card
	  ○ H9 – XLR Card
	• H4 – QC Production Analyzer
	Other
	• KLIPPEL QC PC Requirements
	• KLIPPEL Amplifier Requirements

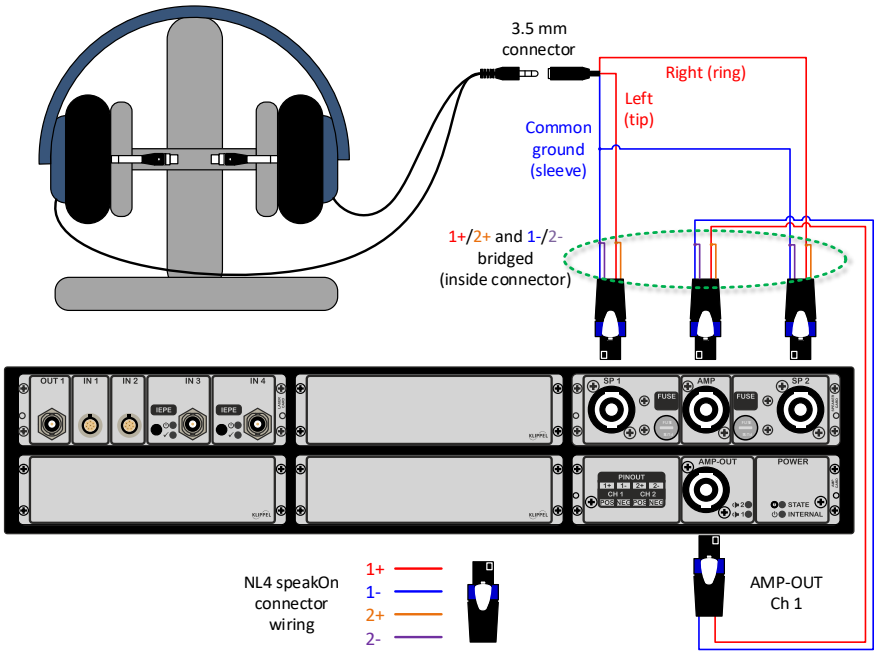
8.3 Example Set	• Example Set for Headphone Quality Control
8.4 Standards	• IEC 60268-7, Sound system equipment, Part 7: Headphones and earphones • IEC 60318-1, Electroacoustics - Simulators of human head and ear - Part 1: Ear simulator for the measurement of supra-aural and circum-aural earphones • IEEE Std 269-2010 - IEEE Standard Methods for Measuring Transmission Performance of Analog and Digital Telephone Sets, Handsets, and Headsets • ITU-T P.581 Use of head and torso simulator for hands-free and handset terminal testing • ISO 4869-3 Acoustics - Hearing protectors - Part 3: Measurement of insertion loss of ear-muff type protectors using an acoustic test fixture. • BS EN 50332
8.5 Application Notes	• AN62 - QC On-line Input Equalization • AN72 - Testing Wireless Audio Devices • AN76 - QC Testing of Wireless Audio Devices All KLIPPEL application notes can be downloaded from our website.
8.6 Related Products	• MSP - Match Speaker Tool • QC MSC - Motor & Suspension Check • QC BAC - Balanced Armature Check • TRF - Transfer Function Measurement • MSPM - Micro Suspension Part Measurement • RMA – Rocking Mode Analysis Find more related modules in the applications section of our website.

9 Appendix

9.1 Custom Cables for Passive Headphones

Since most passive headphones have a common ground for left and right channels, it is required to use customized cables (not provided by KLIPPEL) to connect the DUT to the analyzer and also between amplifier output and analyzer.

Especially when using class D amplifiers (like the KA3 Amp Card), it is important to avoid connecting the grounds of the two amplifier output channels. This would be the case when using the standard stereo amplifier connection cable (with four wires). For this reason, it is recommended to use only one amplifier channel.

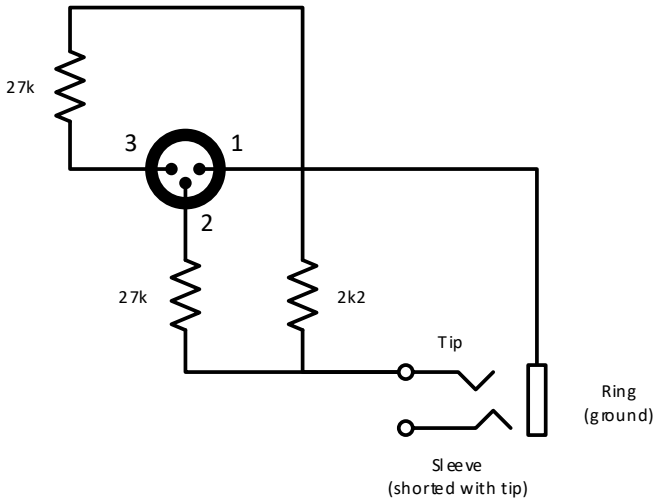


For a stereo amp with LN4 *speakON* output connector (KA3 Amp Card) this is achieved by using only 1+ and 1- wire and bridging the corresponding pins with 2+ and 2- on the analyzer input side (*Speaker Card AMP* input or Production Analyzer AMPLIFIER input). Both speaker output channels are then operated with the identical amplifier channel. Please always make sure that the cable is used with correct orientation to prevent amplifier damage (KA3 Amplifier Card is self-protecting).

The outputs of the *Speaker Card* (or the *Speaker* outputs of the *Production Analyzer*) also use four wires per channel for accurate impedance testing (force lines 1+ / 1- and voltage sense lines 2+ / 2-). Since the transducer terminals are not accessible for optimal four wire impedance measurement (due to the headphone cable), you may connect force and sense lines (1+ with 2+ and 1- with 2-) directly inside the *speakON* connectors. For typical headphone impedances, the error introduced by the cable is negligible or may be considered as a static offset.

9.2 Power Supply Adaptor for Headset Electret Microphone

A simple approach for adapting the 48 V power supply as provided by KA3 XLR Card to a lower supply voltage (e.g. 4 V) for a simple electret condenser microphone of a multi-media headset is given by the circuit diagram below. It may be integrated directly in the adaptor plug (e.g. 3.5 mm jack to XLR male plug).



Note: This circuit assumes that the microphone is wired in a way that tip and ring contacts are shorted in the microphone.

Reference:

http://www.epanorama.net/newepa/2014/06/30/pc-microphone-phantom-powering-improvements/

Find explanations for symbols at:
http://www.klippel.de/know-how/literature.html
Last updated: July 02, 2020