



**ACQUA**



# MDAQS

MDAQS – Measuring operation with ACQUA

# Application Note

MDAQS – Measuring operation with ACQUA

Revision 0

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# 1 Introduction

## 1.1 About MDAQS

MDAQS is a MOS metric for instrumental evaluation of audio quality. It merges the key criteria for perceived audio playback quality – timbre, distortion and immersiveness – into one single MOS value for quick assessment and good comparability. HEAD acoustics developed MDAQS – the Multi-Dimensional Audio Quality Score – based on a tailor-made auditory test design. An algorithm trained with test results calculates a MOS value that reflects the audio quality of arbitrary playback systems or devices, e.g. loudspeakers, headphones & headsets, in-vehicle audio systems, mobile & smart speakers and more. It allows quick and convenient assessment of playback quality for benchmarking or improving arbitrary playback systems or devices. The operation of MDAQS in ACQUA requires purchasing the optional extension ACOPT 36.

## 1.2 Applications

- Automated testing for evaluation and experimental optimization of audio quality in systems & devices with audible playback:
- Multi-channel loudspeaker systems in vehicles & at home
- Earphones, headphones & headsets
- Smart speakers
- Mobile loudspeakers
- One-piece multiroom loudspeakers
- Stereo audio systems

## 1.3 Abstract

Initially, this application note gives a short overview about the scientific background of MDAQS. It describes the development methodology for MDAQS and its analysis metrics that lead to the final result of the calculation. Illustrated measurement configurations instruct about the correct interconnection for various devices. Hereafter, there are instructions about basic settings in ACQUA to perform successful MDAQS measurements and calculations. In the following, the document leads through MDAQS measurement and calculation procedures. There are two procedures. Firstly, the manual procedure that is executed with ACQUALyzer. Secondly, the automatic measurement and calculation of MDAQS with the single measurement descriptor of MDAQS.

## 2 MDAQS – Fundamentals

### 2.1 Background and motivation

Currently there are different approaches and instruments for the professional quality evaluation of audio systems. Nonetheless, these approaches have several limitations.

Auditory assessment includes tests with listeners who evaluate the sound from a device according to specified evaluation criteria. This assessment has several limitations. People have to be recruited, the evaluation may be subjective and inconsistent and it is time consuming and expensive.

Technical measurements deliver results such as frequency response or harmonic distortion. But the interpretation of these results require a lot of expertise and they do not present easy and comprehensible.

MDAQS is an instrumental evaluation method for audio systems. It is based on binaural recordings of real music signals as well as measurement signals. The assessment is based on MOS values. Thus, the results present as numerical values and are very comprehensible, also for non-experts.

### 2.2 Development and structure

#### 2.2.1 Auditory assessment

The assessment principle of MDAQS substitutes the employment of hundreds of human test subjects to assess the quality of audio devices. HEAD acoustics conducted jury studies to gather information about the audio quality assessment behavior of naïve human listeners. The assessment of the MDAQS algorithm is built on this data.

HEAD acoustics used comparison category rating as approach. Thereby, test subjects listen to two audio samples and shall compare them (on a few different parameters) with a preference rating of -3 to +3. This approach also allows to verify the result data by checking for circular triads (test subjects that rate  $A > B > C$  and  $C > A$ ).

Play Sound A

Play Sound B

The **timbre** of Sound A compared to the **timbre** of Sound B is

Much better

Better

Slightly better

About the same

Slightly worse

Worse

Much worse

The **amount of distortion** of Sound A compared to the **amount of distortion** of Sound B is

Much better

Better

Slightly better

About the same

Slightly worse

Worse

Much worse

The **immersiveness** of Sound A compared to the **immersiveness** of Sound B is

Much better

Better

Slightly better

About the same

Slightly worse

Worse

Much worse

The **overall quality** of Sound A compared to the **overall quality** of Sound B is

Much better

Better

Slightly better

About the same

Slightly worse

Worse

Much worse

The test subject assessed three different quality attributes for music samples played back on audio devices:

- Timbre
- Distortion
- Immersiveness

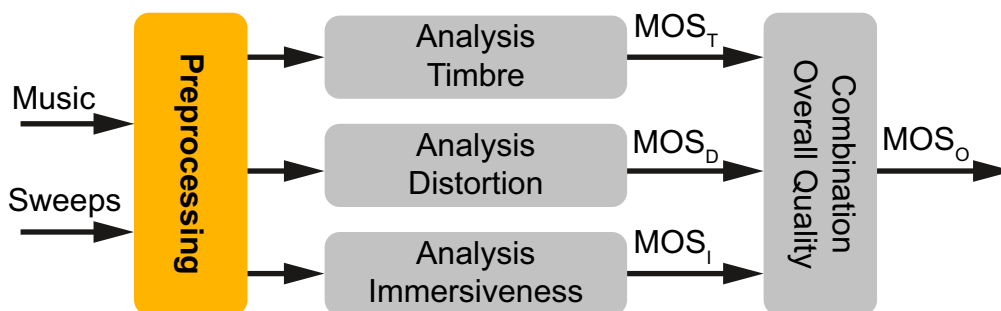
These three attributes justify an overall quality impression.

## 2.2.2 Mean Opinion Score

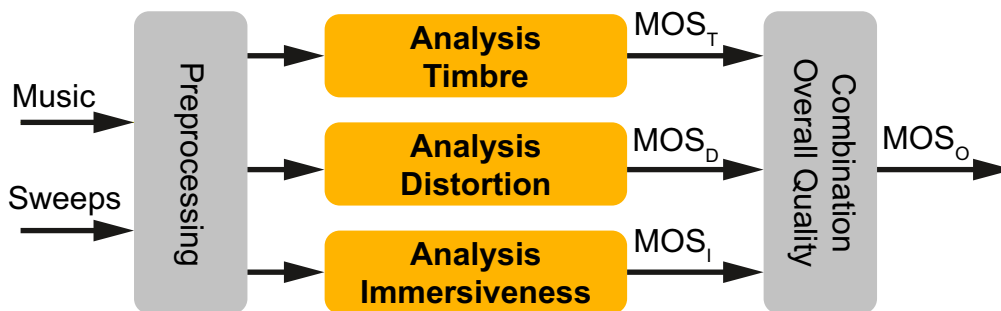
MDAQS calculates a result that is a numerical value based on the ranking system Mean Opinion Score (MOS) from Recommendation ITU-T P.800. The Mean Opinion Score ranges from five (best value) to one (worst value). Result values are not limited to integers. They may have one decimal digit (e.g. 3.6).

MOS value	Quality
5	Excellent
4	Good
3	Fair
2	Poor
1	Bad

## 2.2.3 Preprocessing



The input signal consists of different signal types. It has two channels. Two sine sweeps (20 Hz - 20 kHz) play back one by one. The sweeps play back on different channel. Then 2-channel music samples play back. These are the same music samples that were used in the jury studies. Afterwards, MDAQS performs basic operations like identification of sampling rate, alignment and level adjustment.



## 2.2.4 Timbre

MOS-T (Timbre) represents the spectral properties of the transmission system and the temporal resolution.

The timbre analysis comprises of various metrics:

- Delta in frequency response: The frequency response of the device under test is compared to a target frequency response that derives from the auditory assessment. The metric calculates a quality value from the comparison.
- Spectral flux indicates the reproduction of the signal's temporal structure by the device under test.
- Comparison between source signals and recorded signals of important frequency bands for the listener to evaluate the audio quality of the device under test:
  - Bass (50 Hz - 250 Hz)
  - Upper midrange (2 kHz - 4 kHz)
- Hearing model by HEAD acoustics to capture many capabilities and phenomena of the human hearing system.

## 2.2.5 Distortion

MOS-D (Distortion) represents non-linearities and additive noise.

The distortion analysis comprises of various metrics:

- Delta in frequency response: The frequency response of the device under test is compared to a target frequency response that derives from the auditory assessment. The metric judges the importance of signal sections. A device under test may not transmit in certain frequency bands and hence there are no measurable distortions.
- Harmonic distortion
- Analysis of the spectrogram of the sweep measurement (looking for non-linearities in the transmission).
- Modulation spectra

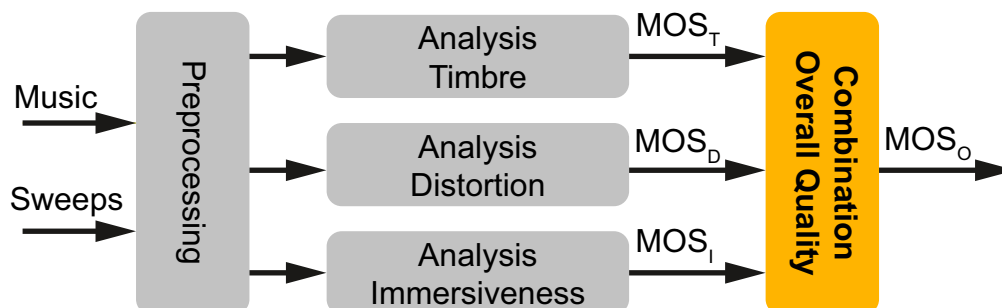
## 2.2.6 Immersiveness

MOS-I (Immersiveness) represents source width and source position.

The immersiveness analysis comprises of various metrics:

- Delta in frequency response: The frequency response of the device under test is compared to a target frequency response that derives from the auditory assessment. The metric calculates a quality value from the comparison.
- Spectral flux indicates the reproduction of the signal's temporal structure. This is important for spatial perception of the audio signal.
- Comparison of spectral content in the upper mid-range frequency band which is very important for human listeners.
- Binaural hearing model: Two variants of differences between correlograms. The model quantifies the spatial perception of a human listener.

## 2.2.7 Overall quality



MOS-O (Overall) represents the overall quality impression calculated from MOS-T, MOS-D and MOS-I.



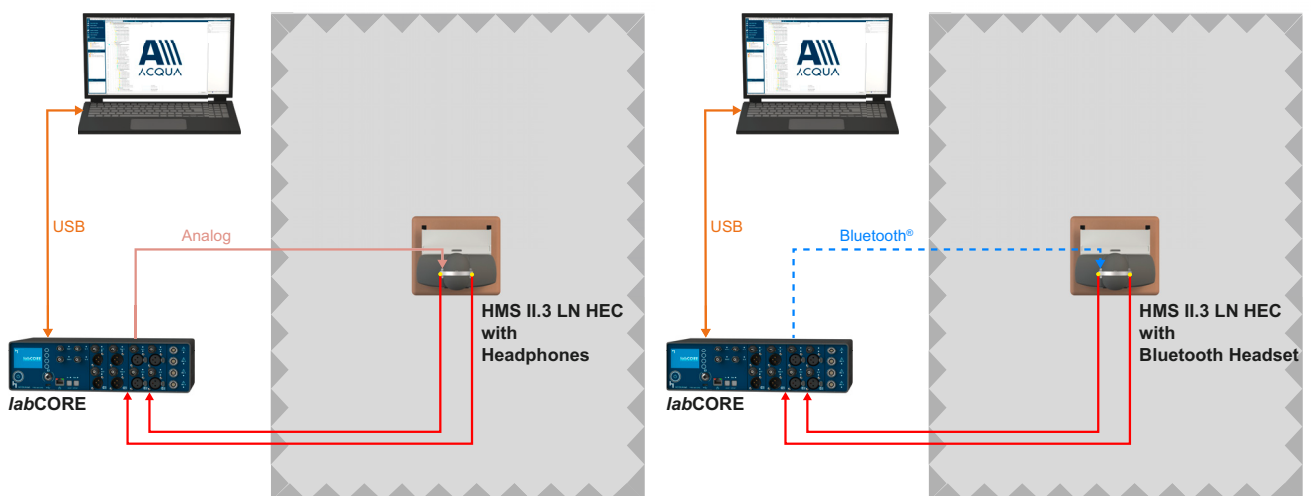
## 3 MDAQS – Configurations and measurements

### 3.1 Measurement configurations

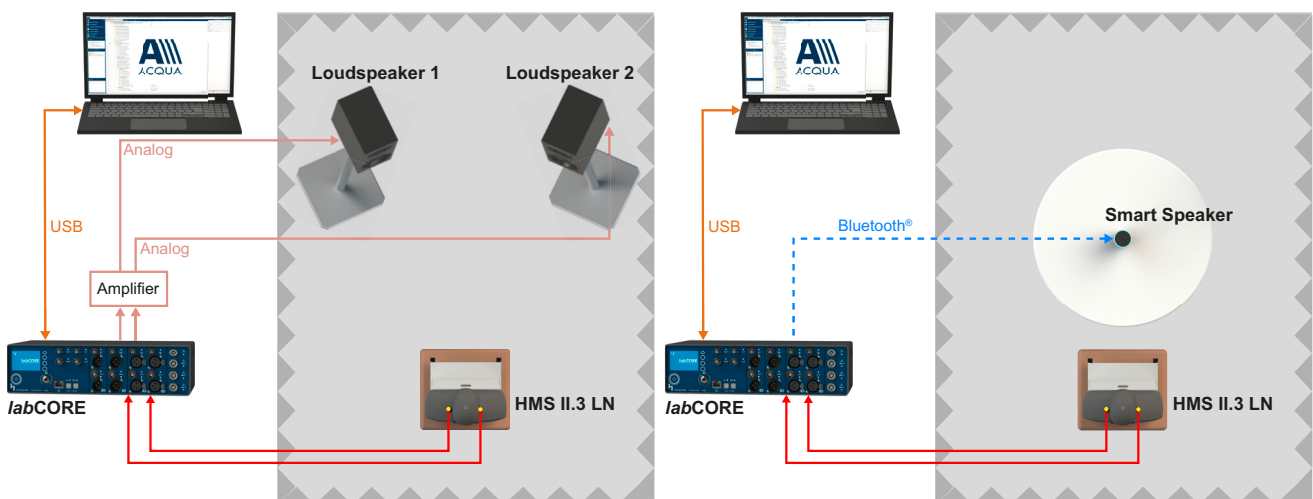
This chapter presents some exemplary measurement configurations for MDAQS. They do not capture the whole scope of application for MDAQS. All possible applications share the usage of the binaural artificial head, an appropriate hardware platform and ACQUA. The interconnection of the DUT depends on its customized technical properties. *labCORE* and its extension levels provides connections for all common audio interfaces.

The positioning of the DUT in relation to the artificial head is obvious for headphones / headsets and motor vehicles. For headphones / headset, put the DUT over or into the ears, according to the headphones / headset design. In a motor vehicle, loudspeakers are usually fixed in a determined position. Nonetheless, it is possible to measure MDAQS results for driver or passenger positions by relocating the artificial head. The position of movable loudspeakers shall be application-oriented within the limits of the measurement cabin.

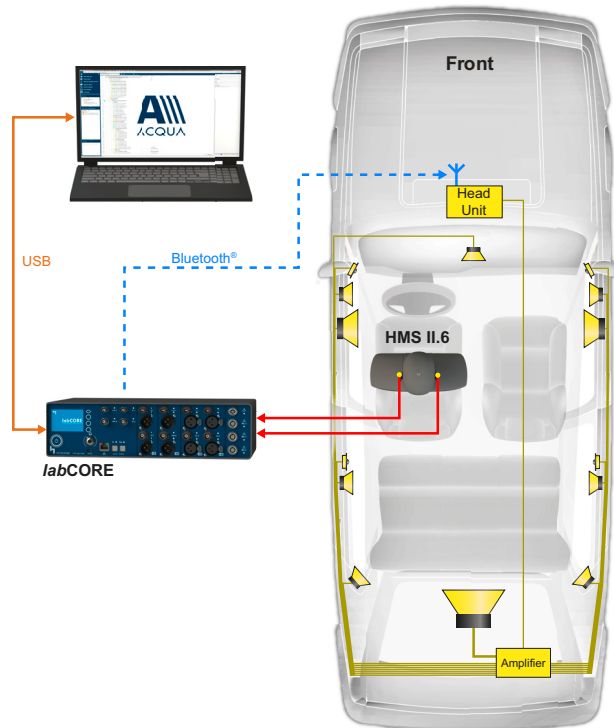
#### 3.1.1 Analog / Bluetooth headphones (exemplary)



#### 3.1.2 Analog / Bluetooth loudspeaker (exemplary)



### 3.1.3 Automotive



## 3.2 ACQUA – Hardware configuration

### 3.2.1 Workplace settings

1. Open Workplace Settings.
2. Set up desired HATS for the measurement.
3. Assign desired HATS.

### 3.2.2 labCORE options

1. Open labCORE Options.
2. Go to Microphone Options.
3. Select the appropriate supply voltage for ear microphones of the HATS.
4. Apply polarization voltage for ear microphones of the HATS.

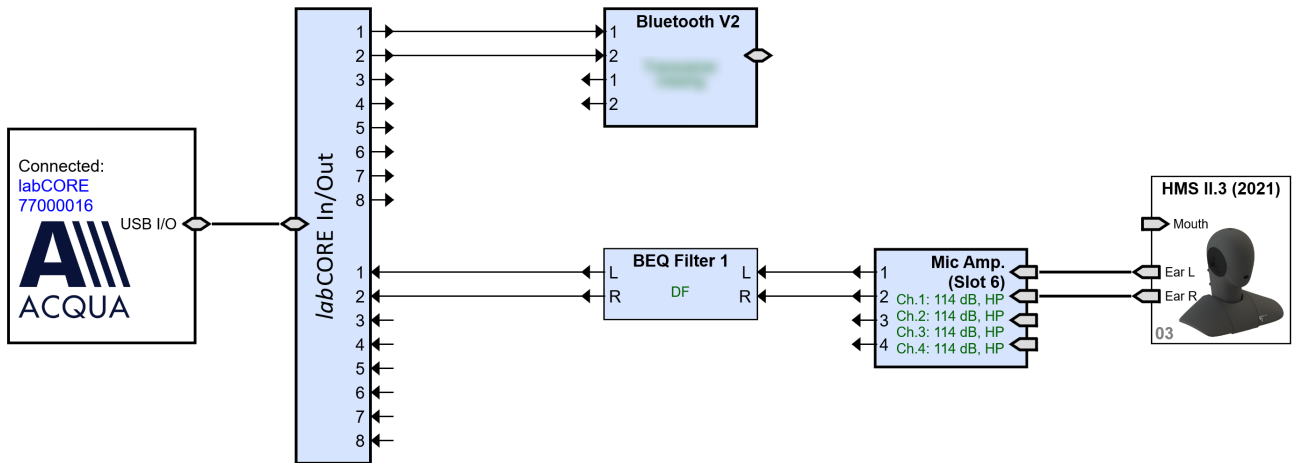
### 3.2.3 General settings

- Connect right and left ear microphones of the assigned HATS to the applied microphone amplifier block.
- The connection block for the applied DUT depends on the available interfaces of the DUT (e.g. Bluetooth, USB, Analog).

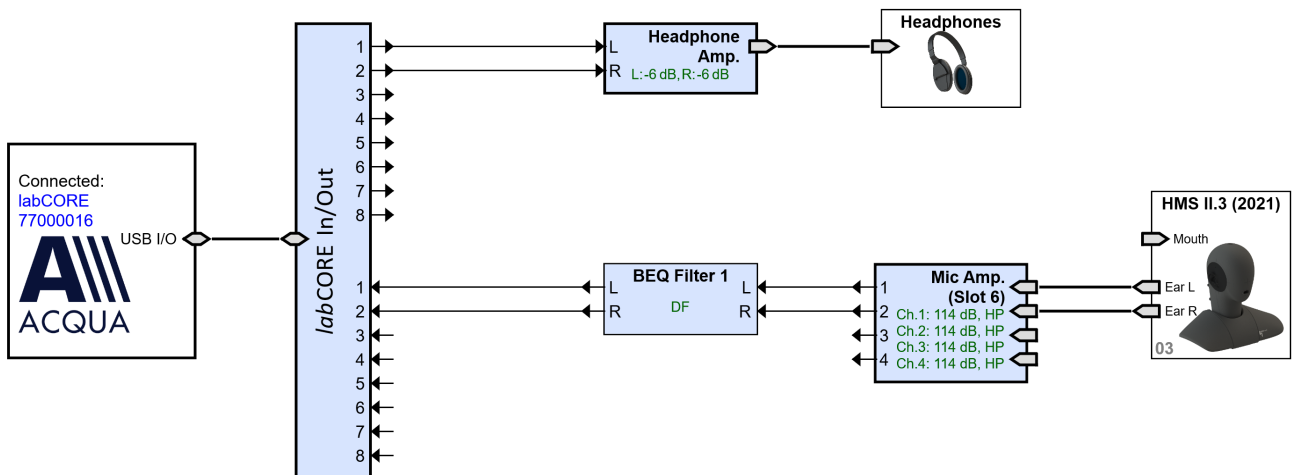
### 3.2.4 BEQ Filter

1. Apply the BEQ filter block.
2. Enable BEQ filter for both ear microphones.
3. Set the BEQ filter to diffuse field equalization (DF).

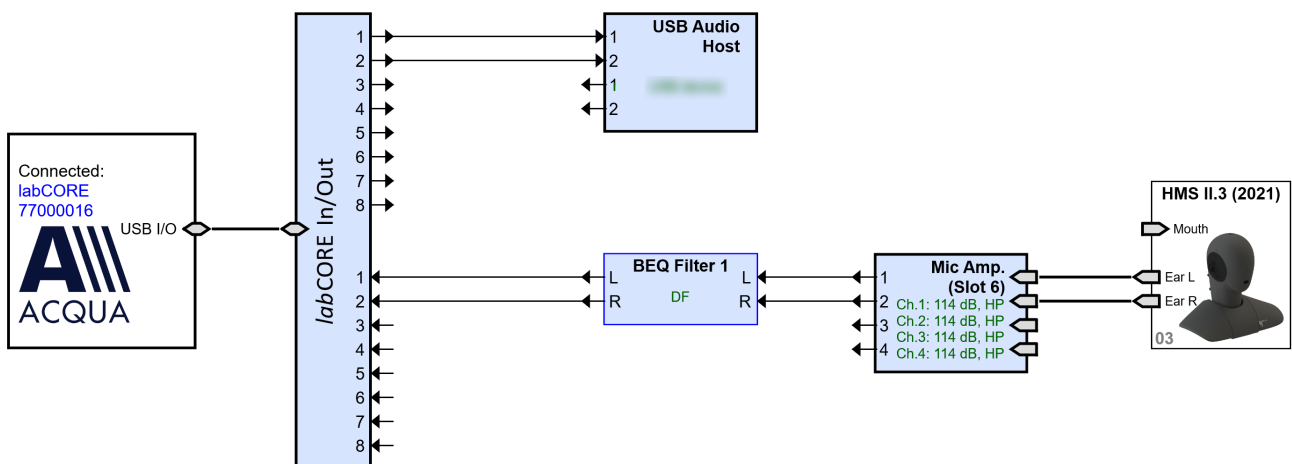
### 3.2.5 Bluetooth configuration (exemplary)



### 3.2.6 Analog configuration (exemplary)

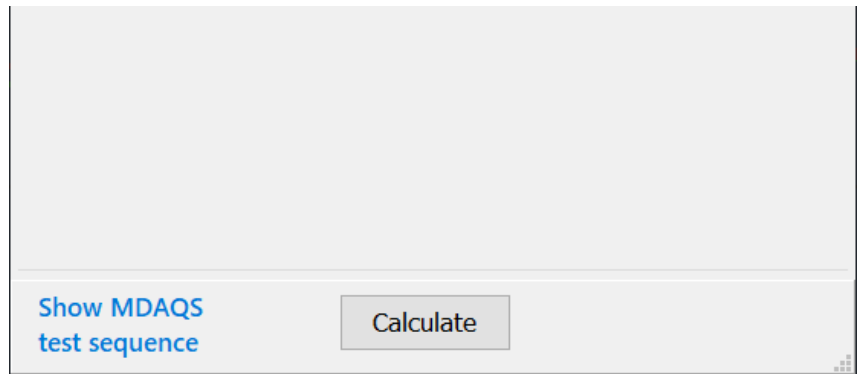


### 3.2.7 USB configuration (exemplary)

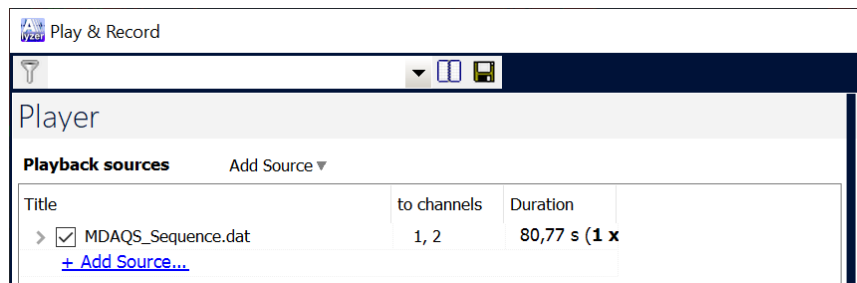


### 3.3 MDAQS measurements via ACQUAlyzer

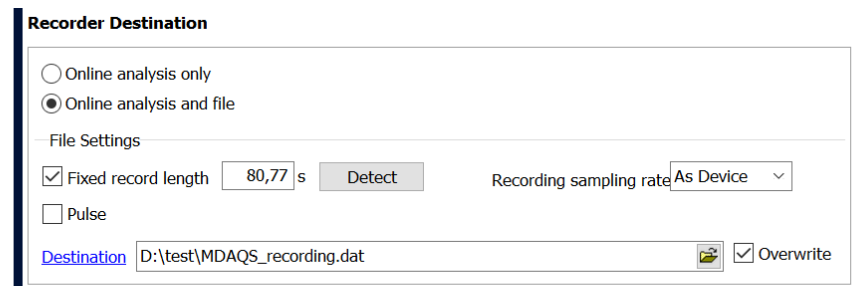
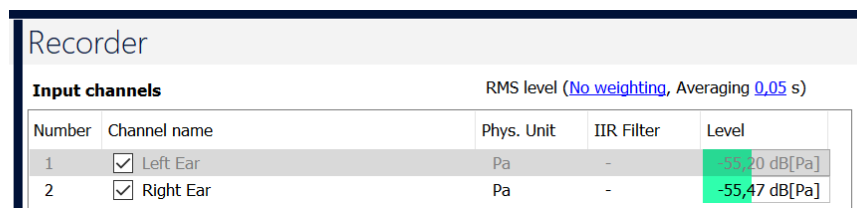
1. Open ACQUAlyzer.
2. Select F5.
3. Set up the appropriate hardware configuration.
4. Close Hardware Configuration.
5. Select Calculation → MDAQS.
6. Select Show MDAQS test sequence.
7. Close MDAQS window.
8. Right-click on the Time Window in ACQUAlyzer.
9. Select Edit Header.
10. Note the file path of the MDAQS test sequence (e.g. C:\Program Files (x86)\HEAD Analyzer ACQUA).
11. Select Audio → Play / Record.
12. Playback sources: Select Add source... → Add files...
13. Browse to the file path of the MDAQS test sequence.
14. Select MDAQS\_sequence.dat.



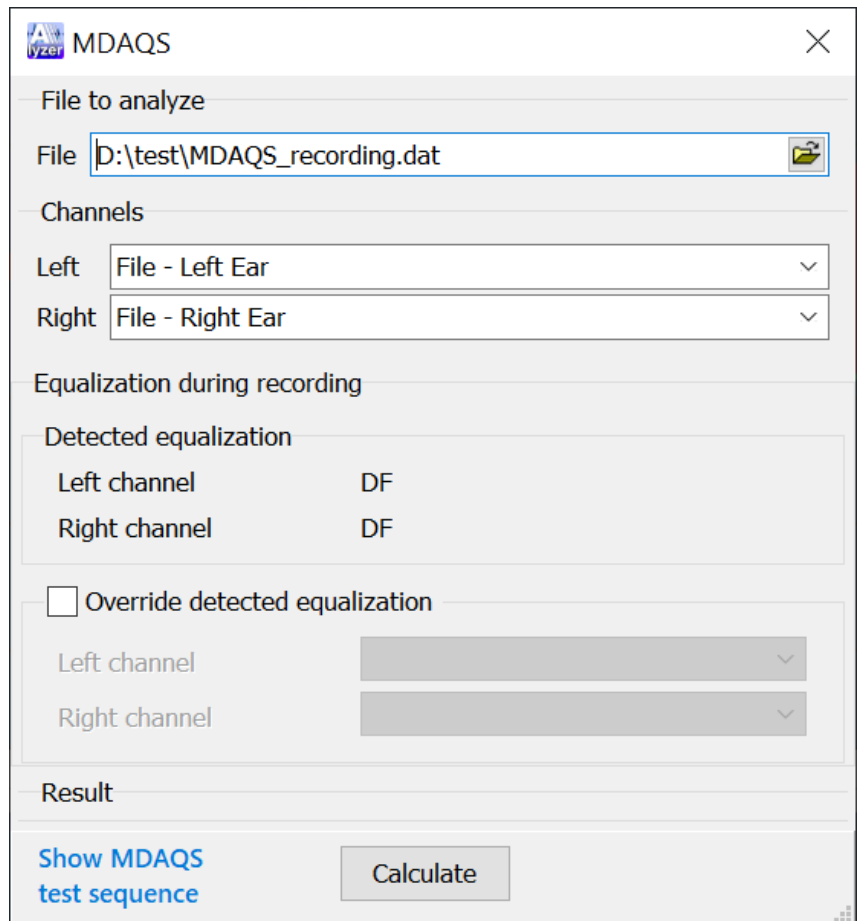
15. Input channels: Enable both input channels.



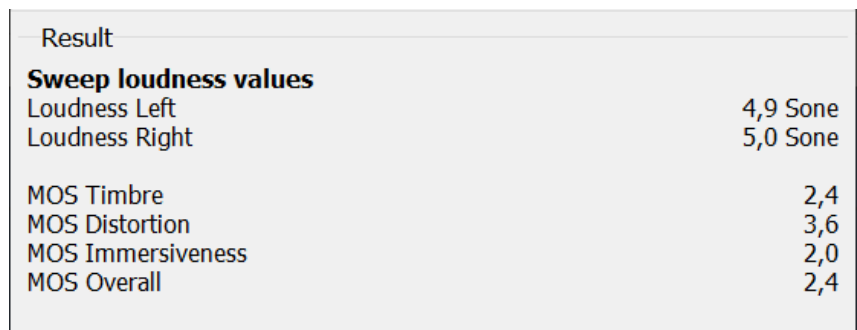
16. Recorder Destination: Select Online analysis and file.
17. Enable Fixed record length and select Detect.
18. Select the desired file path for the MDAQS recording.
19. Select Play & Record to start recording.
20. Wait until the recording is over.
21. Close Play & Record.



22. Select Calculation → MDAQS.
23. File: Browse for the MDAQS recording.
24. Channels: Assign the channels appropriately.
25. Optional: Enable Override detected equalization.  
Select the desired equalization from the drop-down list for left and right channel.
26. Select Calculate to start the MDAQS calculation.

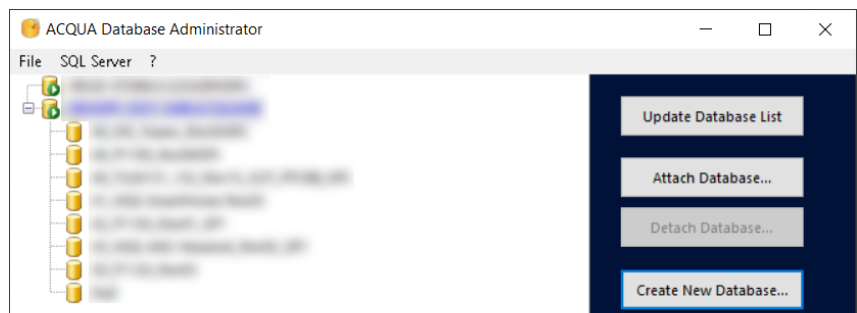


27. The results appear in the respective field at the bottom after the successful calculation.

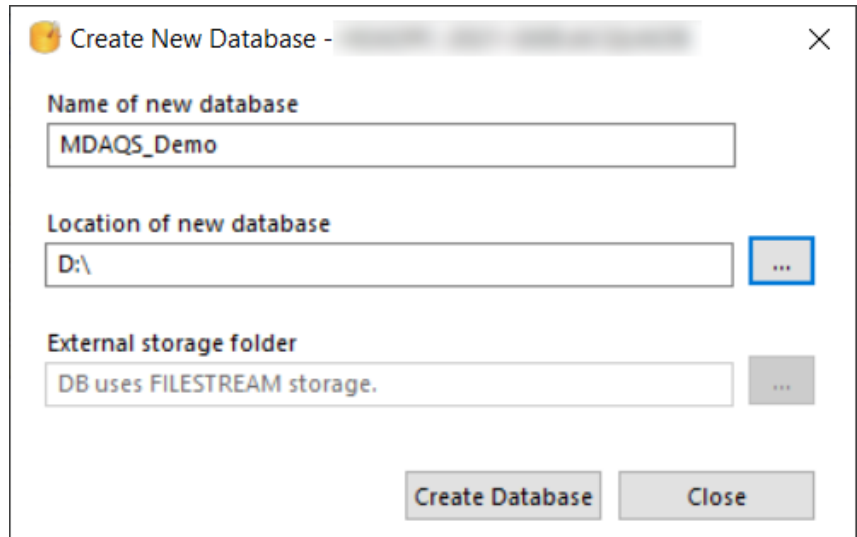


### 3.4 MDAQS measurement via Single Measurement Descriptor

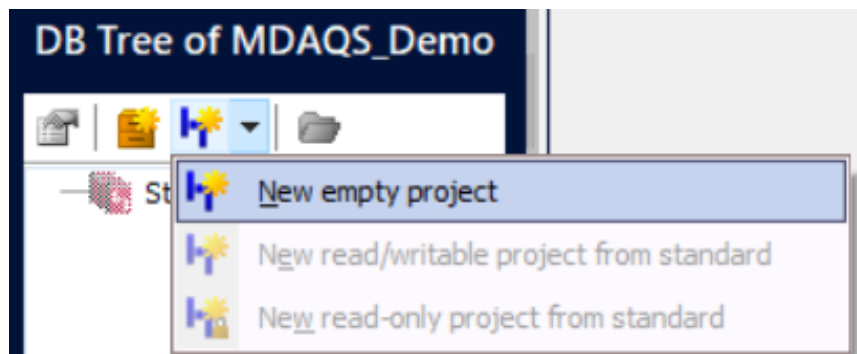
1. Open ACQUA quick start.
2. Select Database Tasks.
3. Open Database Administrator.
4. Select Create New Database...



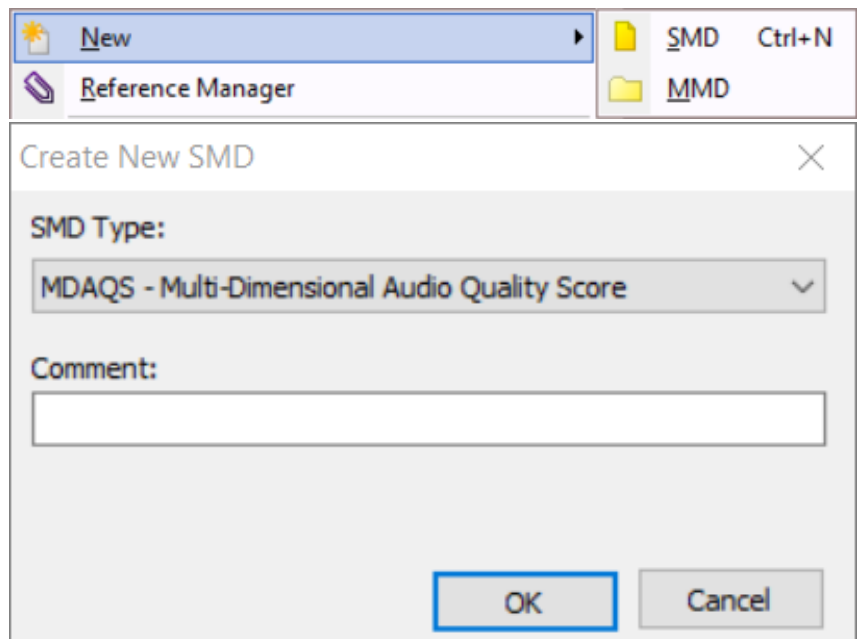
5. Enter a name for the database.
6. Select the desired location for the database.
7. Select Create Database.



8. Go to project tree overview.
9. Select the database from Server Tree.
10. Create New project.
11. Select F5.
12. Set up the appropriate hardware configuration.
13. Close Hardware Configuration.



14. Right-click on server tree.
15. Select New → SMD.



16. Select MDAQS - Multi-Dimensional Audio Quality Score from the drop-down list as SMD type.
17. Confirm with OK.

Use the SMD Editor to customize the measurement. No amendments are necessary for a standard MDAQS measurement.

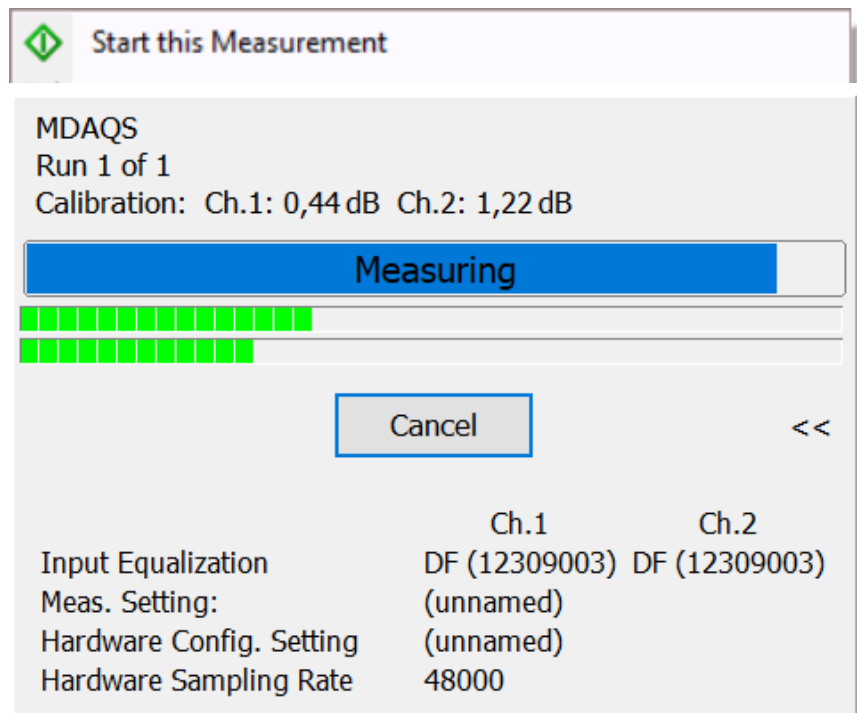
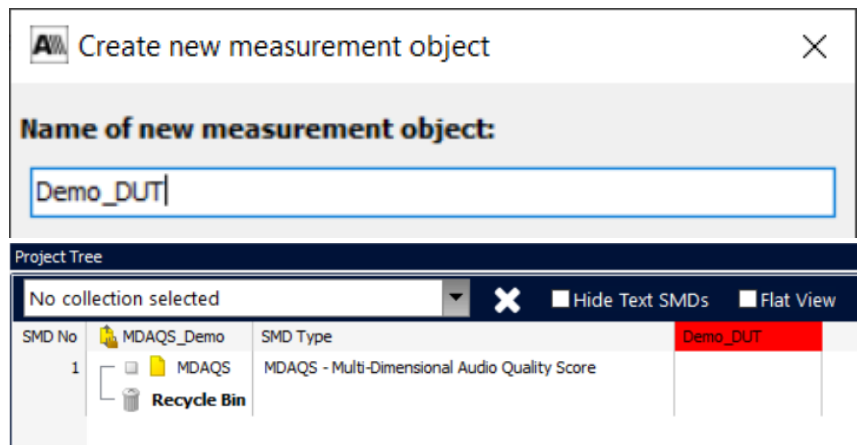
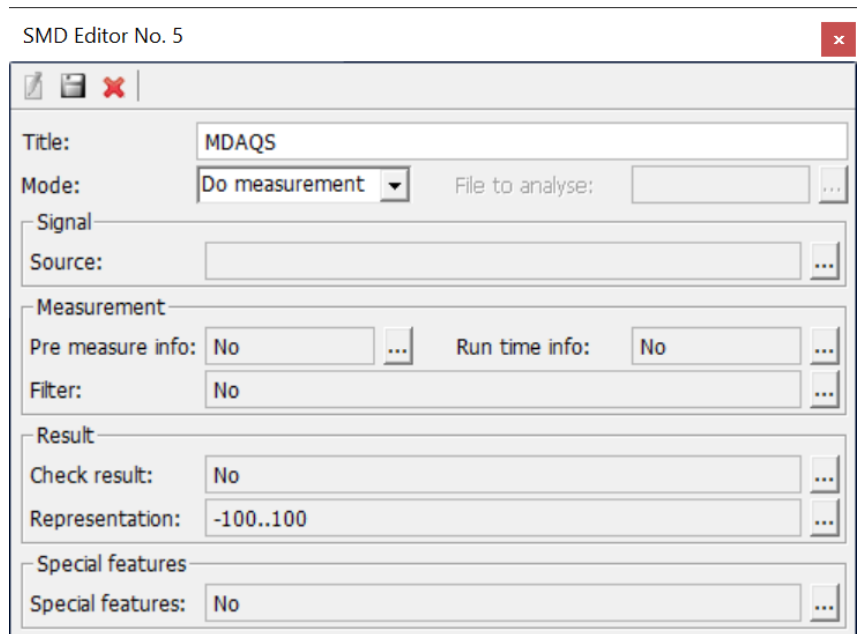
- Title → Customize the title of the SMD.
- Mode → Select desired mode.
  - Do measurement → ACQUA executes recording and following analysis.
  - Analyse existing file → ACQUA only analyses a former MDAQS recording.

Refer to ACQUA Online Help → ACQUA → SMD → Frequent parameters for further information.

18. Create new measurement object for the database.
19. Activate Measurement object in project tree.
20. Right-click on the MDAQS SMD.

21. Select Start this Measurement.

22. The measurement proceeds automatically.



23. The calculation / analysis proceeds automatically after the measurement.

	Ch.1	Ch.2
Input Equalization	DF (12309003)	DF (12309003)
Meas. Setting:	(unnamed)	
Hardware Config. Setting	(unnamed)	
Hardware Sampling Rate	48000	

24. ACQUA presents the results in a new window.

• MDAQS			
Loudness Left	1,2 Sone	Loudness Right	1,2
Sone			
MOS Timbre	4,6	MOS Distortion	3,4
MOS Immersiveness	3,7	MOS Overall	4,2