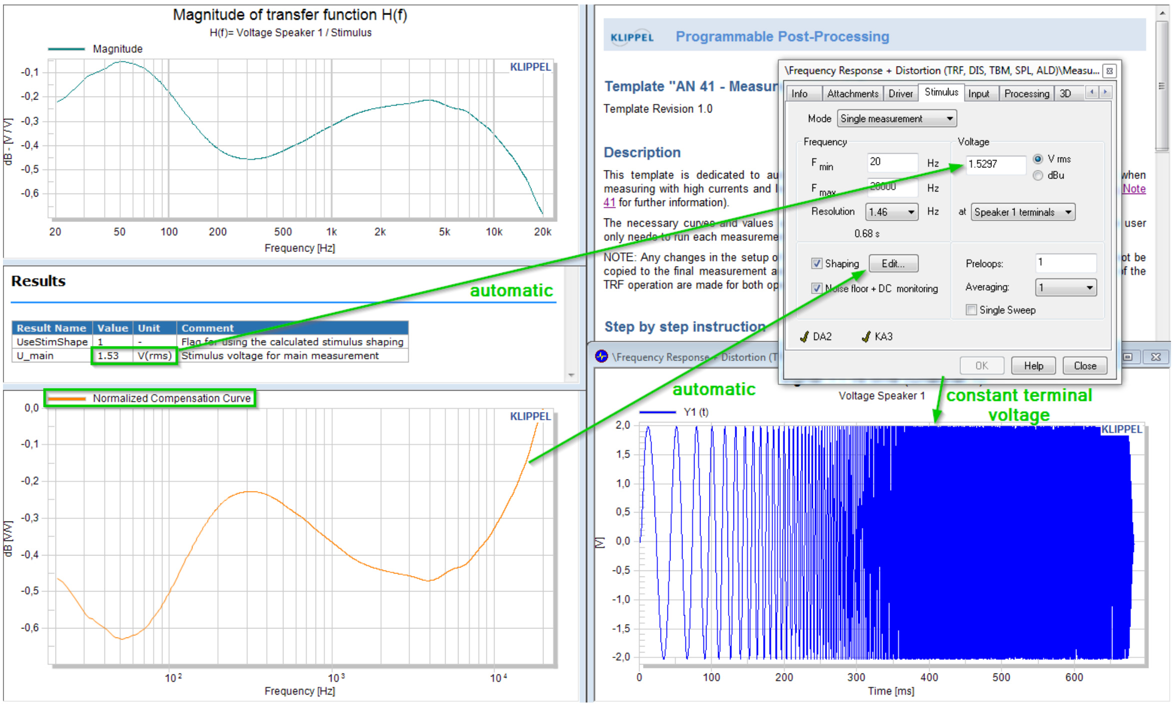
# Measurement at defined terminal voltage AN 41

Application Note to the KLIPPEL ANALYZER SYSTEM (Document Revision 1.3)




When a loudspeaker is operated via a power amplifier, cables, connectors, and clips the voltage at the terminals is not identical to the ideal stimulus in the generator. However, some measurements (e.g. distortion measurements) need a precise value and a constant voltage frequency response at the electrical terminal. This problem can be solved by applying a shaping to the stimulus in the TRF module or in the SPL task in case of a QC application. In the latter case, the shaping curve is measured with the EQA module and is added to the stimulus in the SPL task automatically.

This Application Note is a step-by-step description of how to do such a measurement by using the according dB-Lab templates.

CONTENTS:

1 Introduction ... 2
2 Using KLIPPEL RnD Software ... 5
2.1 Requirements ... 5
2.2 Procedure ... 5
3 Using KLIPPEL QC Software ... 7
3.1 Requirements ... 7
3.2 Procedure ... 8
4 More Information ... 10

# 1 Introduction

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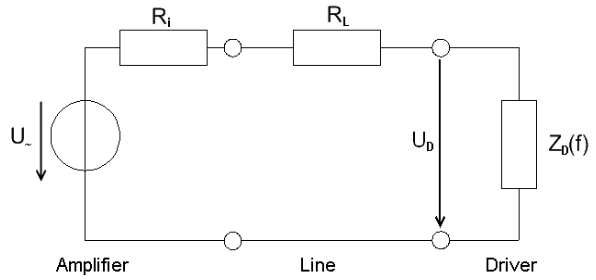
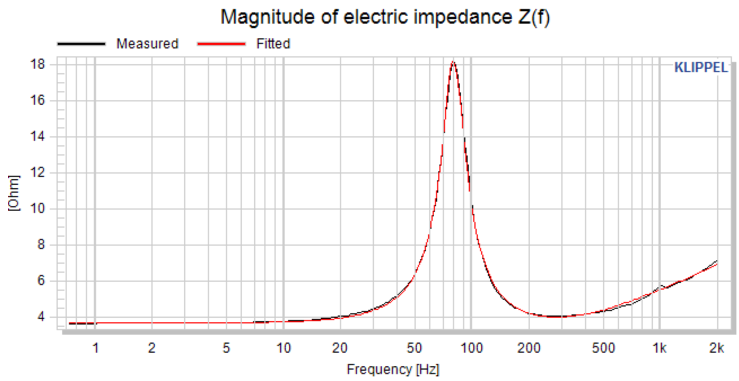
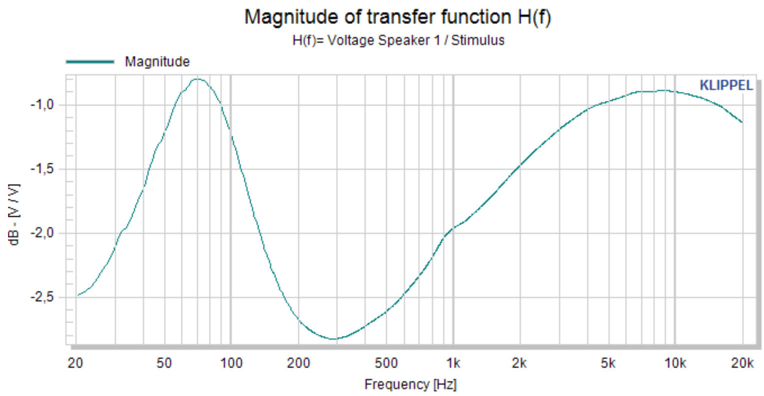
|---|---|
| **Problem** |   **Equivalent circuit explaining voltage variation at the terminals**<br>The generation of nonlinear distortion in loudspeakers depends on the amplitude of the electrical stimulus (usually the voltage $U_D$ at the terminals).<br>The voltage at the terminals depends on<br>• The transfer function between input and output of the power amplifier. Conventional ac-coupled amplifiers have a high-pass characteristic to prevent very low frequencies.<br>• The output impedance of the power amplifier.<br>• The resistance of the cables, connectors and clips used between amplifier and DUT.<br>• The electrical input impedance of the DUT. |
| **Electrical input impedance** |   The electrical input impedance $Z_D$ of the DUT varies significantly versus frequency due to the effect of the mechanical resonance and the electrical inductance of the voice coil. Thus, the current flow through the speaker cable varies a lot over frequency (low current at resonance and at higher frequencies). |

<table>
<tr><td>Voltage error</td><td>


<br>
The KLIPPEL Analyzer hardware provides a four-wire sensing technique to measure the precise voltage at the DUT terminals. The deviation between target voltage and real voltage at the terminals is not critical if a linear transfer function is measured in the small signal domain and the output signal (pressure) is divided by the input signal (voltage at the terminals). However, a deviation of 0.5 dB may cause already a significant error in the measurement of nonlinear distortion.
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<tr><td>Shaping the Stimulus in TRF module</td><td>
The Klippel TRF module does not just provide a measurement with a constant stimulus voltage covering the full bandwidth, but it’s also possible to vary the voltage in terms of the frequency with any function by applying a SHAPING to the stimulus.
<br><br>
This shaping curve has to be given as a two-column matrix with the frequency in the first column and its according amplitude in dB in the second column. This will change the shape of the stimulus spectrum accordingly. For security reasons, the shaping curve is automatically normalized to a maximum of 0 dB, i.e. the stimulus amplitude will never be higher than defined in the properties of the TRF (parameter Voltage).
<br><br>
Thus, to compensate for the general attenuation and to realize the desired target voltage at the speaker terminals the parameter Voltage has to be increased.
<br><br>
Both parameters (shaping curve and target voltage) will be set by the semi-automatic process using the PPP module (see section 2 Using KLIPPEL RnD Software).
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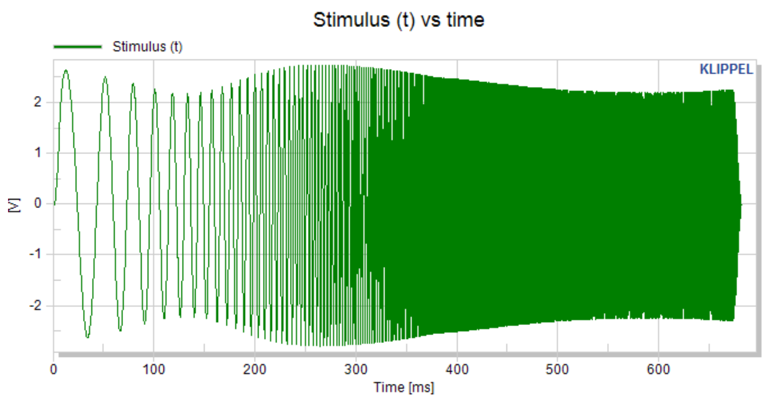

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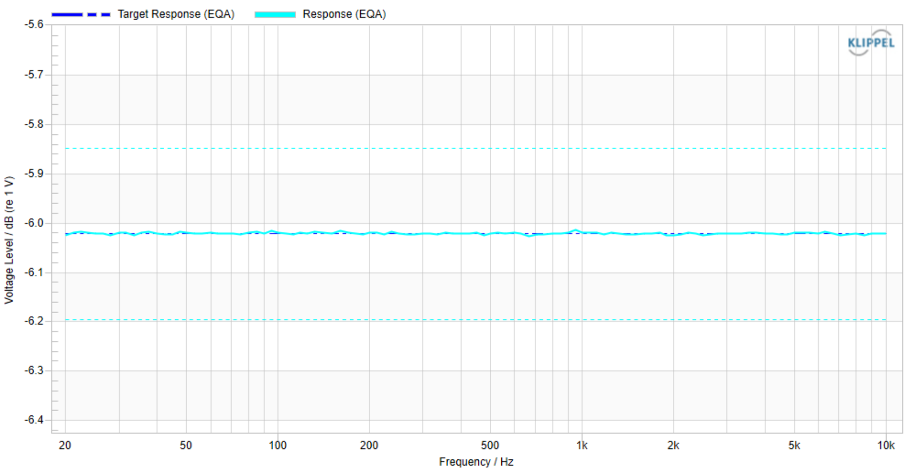
| **Automatic alignment in the SPL +EQA task** | Compared to the TRF module, the QC Equalization + Alignment (EQA) provides a simple and automatic way for stimulus shaping.<br>After defining the target response by the user, the EQA task will repeat and adjust the control parameters iteratively until the desired response is achieved. After successful equalization, the corresponding settings including the shaping curve (level profile) are exported to a .klpar parameter file. This file will then be imported to the SPL task and the settings will be updated and applied to get desired results such as frequency response, and THD at the defined constant terminal voltage.<br>The following chart shows the equalized voltage response for a defined target response of 0.5 V and the tolerance profile of [*, -0.01, 0.01].<br> |

# 2 Using KLIPPEL RnD Software

## 2.1 Requirements

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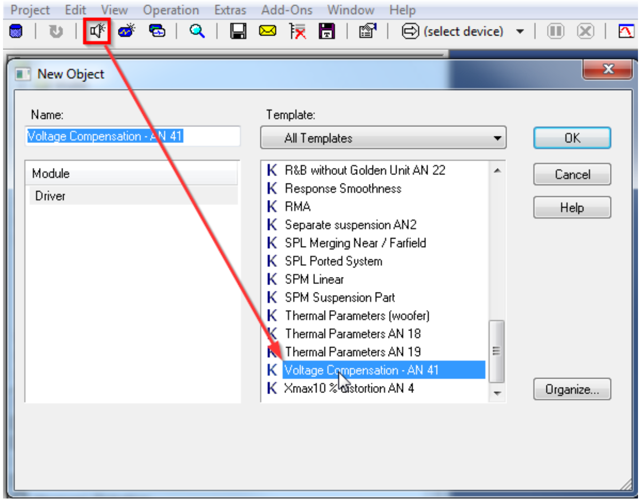
| **Hardware / Software** | To perform TRF measurements with voltage compensation, the following hardware and software is required: | |
| | **Hardware:** | ○ Klippel Analyzer hardware (DA1, DA2 or KA3) |
| | **Software:** | ○ dB-Lab 210 or higher * |
| | **Licenses** | ○ TRF – Transfer Function (Standard or Pro)<br>○ PPP – Programmable Post-Processing |
| **Preparation** | • Create a new object in dB-Lab and select the Voltage Compensation template to start the analysis<br><br>• Enter the sensitivity of the microphone in property page *Input* for the operation *3 TRF main measurement* or use a pistonphone to calibrate the microphone (using TRF operation template *TRF mic calibration for IN1*).<br>**Note:** This step is not needed for dB-Lab 212 or higher since the microphone calibration is stored in dB-Lab globally. | |



* For dB-Lab version ≤ 206 there is an older version of this AN available. Please contact support@klippel.de

## 2.2 Procedure

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|---|---|
| **1 Pre Measurement of Voltage at Terminals** | **Motivation:** We start with a simple TRF measurement of the loudspeaker under test to obtain the voltage transfer function which considers the complete setup (amplifier, cables and loudspeaker). This transfer function is needed afterward to generate the stimulus shaping curve.<br>**How to do it:** In *1 TRF pre-measurement* select *Properties* → *Stimulus* and determine your stimulus voltage as you require for your main TRF measurement.<br>Specify your maximum bandwidth ($F_{min}$ and $F_{max}$) you will also use for the main measurement.<br>Run the *TRF pre-measurement*.<br>Make sure that you have selected the transfer function $H(f) = Us / Stim$ in *Properties* → *Processing* and use *No Window*. |
| **2 Calculating the Shaping Function** | **Motivation:** This operation will calculate the optimal shaping function and a new stimulus voltage that compensates for the attenuation in the shaping function. |

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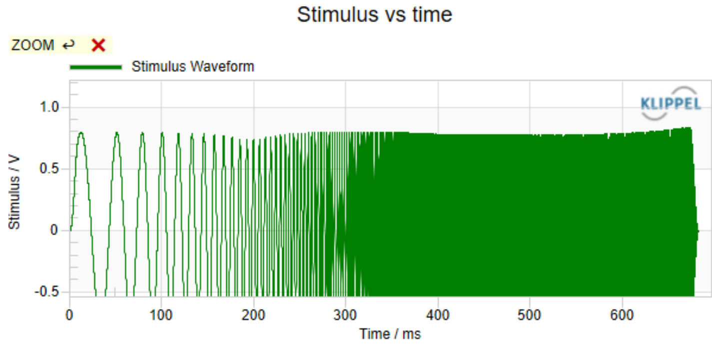


**How to do it:** Run the operation *2 PPP Shape function*.

The shaping function and new stimulus voltage will be calculated and exported automatically to the final TRF measurement.

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**3 Main Measurement**

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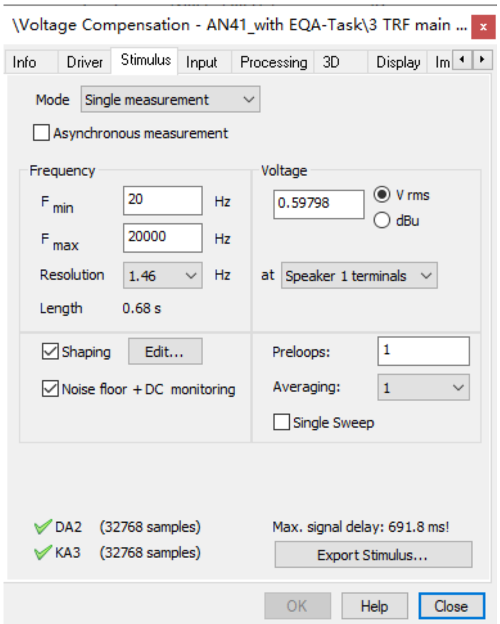
**Motivation:** The shaping function and stimulus voltage should match the calculation results of the PPP operation. With this shaping you can run the main measurement with constant voltage




**How to do it:** Make sure you are using the same stimulus settings as in the TRF pre-measurement and run the main measurement.

Keep in mind that your Stimulus is not constant. If you want to demonstrate your H(f) magnitude in terms of the constant voltage at the terminal you have to select *Us* as denominator in *Properties* → *Processing*!

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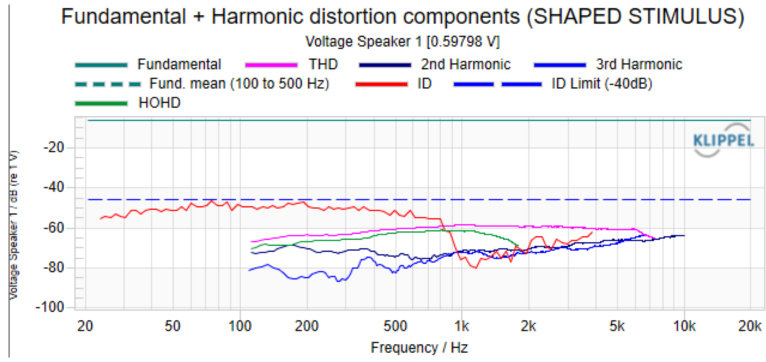
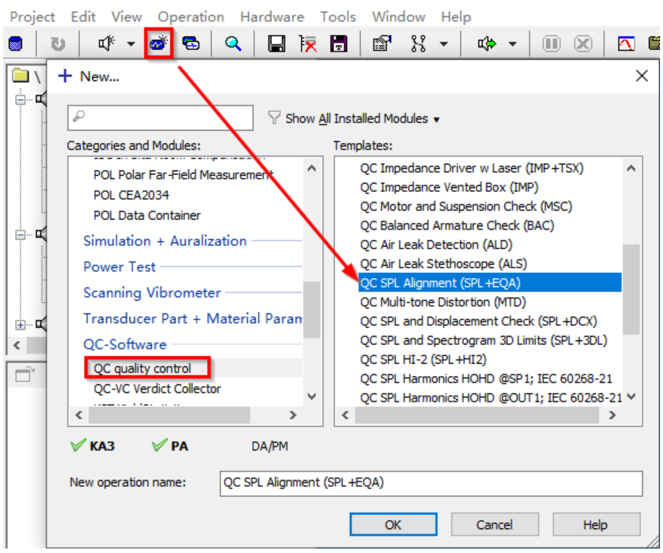
| **Result:** |   A flat voltage response can be realized at the terminals of the loudspeaker by shaping the stimulus. Thus, the results of the distortion measurements are independent on the transfer response of the amplifier, output impedance of the amplifier, cable length and electrical input impedance of the loudspeaker.<br>**Note:** This stimulus shaping is only valid for the combination of this particular DUT, amplifier, and cables. It may also change with temperature. So, you should repeat the complete sequence when repeating the measurement. |

# 3 Using KLIPPEL QC Software

## 3.1 Requirements

| | | |
|---|---|---|
| **Hardware / Software** | To perform SPL measurements with voltage compensation using the SPL task, the following hardware and software is required: | |
| | **Hardware:** | ○ Klippel Analyzer hardware (PA2 or KA3) |
| | **Software:** | ○ QC7 (dB-Lab 212) or higher |
| | **Licenses** | ○ SPL – Sound Pressure Task<br>○ EQA – Equalization & Alignment Task<br>○ (in RnD environment) license QCforRnD |
| **Preparation** | **In RnD environment:**<br>Create a new QC Operation based on the template *QC SPL Alignment (SPL+EQA)*   |

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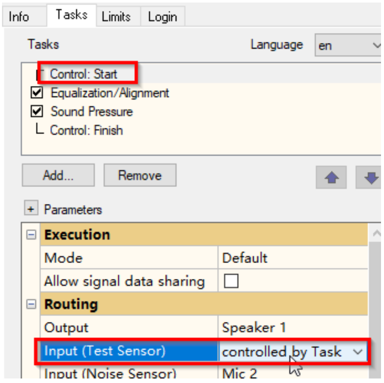
| | **In EoL environment:** Create a new test in QC Start from an empty test template and add the EQA task and SPL as you can see in the below section. Please note, that you have to add an EQA task for every SPL task in the test sequence (not only one EQA task in case of multiple SPL tasks). In the end, you can save this test sequence as your own user template via the QC Start menu *Test → Save as Template*. |

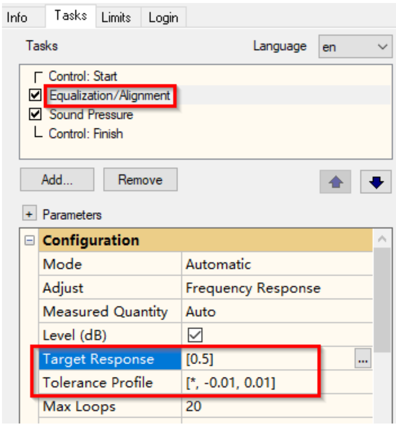
## 3.2 Procedure

**Measurement**

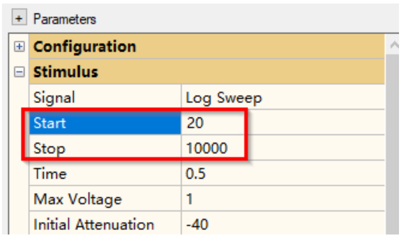
1) Start the QC Operation (Login).
2) Select Control: Start and set *Input (Test Sensor)* to *controlled by Task* in section **Routing**.



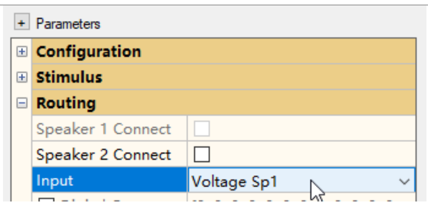

3) Select the EQA task and enter your *Target Response* and the *Tolerance Profile* in section **Configuration**. Please refer to the manual of the EQA task for further information about these parameters.




4) Adjust the *Start* and *Stop* frequency in section **Stimulus** according to your application.



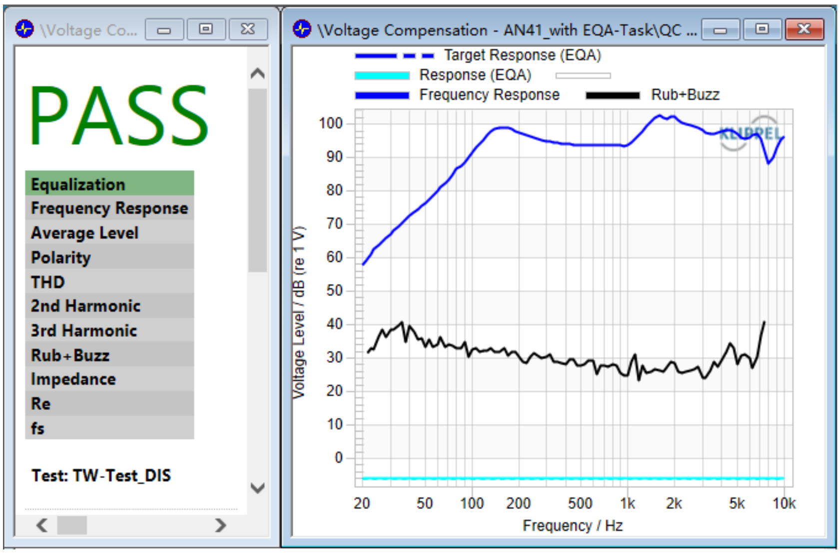

5) Set *Input* to *Voltage Sp 1* in section **Routing**.



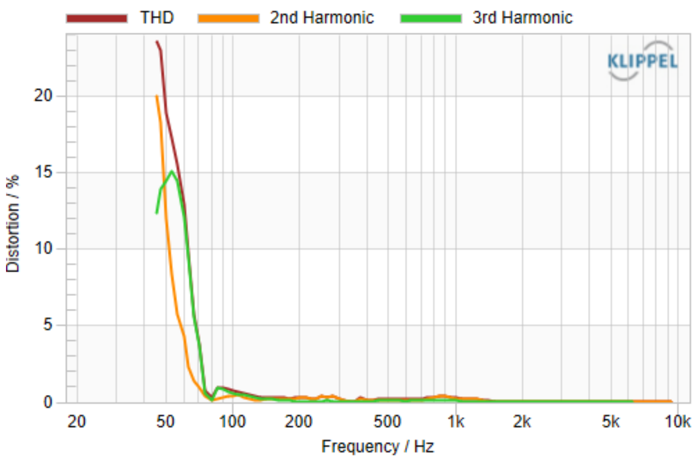

6) Start the measurement.

**Note:** The settings of the SPL task will be automatically imported from the EQA task. You most likely do not need to change the SPL task settings.

**Result:**




The equalized voltage response can be achieved with the EQA task and is shown in dB in the result window *Frequency Response* (the lower bright blue curve) . It can be then applied to the loudspeaker in the SPL task and the corresponding frequency response is measured by the microphone and shown in the same result window (the upper blue curve). Other results such as THD, harmonics and average level can also be measured by activating them as results in the SPL task.



# 4 More Information

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|---|---|
| **Related Modules** | Transfer Function Measurement (TRF)<br>Programmable Post-Processing (PPP)<br>Equalization & Alignment (EQA)<br>Sound Pressure (SPL)<br>Sound Pressure and Impedance (SPL-IMP) |
| **Software** | User Manual of the KLIPPEL R&D and QC System |

Find explanations for symbols at:
http://www.klippel.de/know-how/literature.html
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