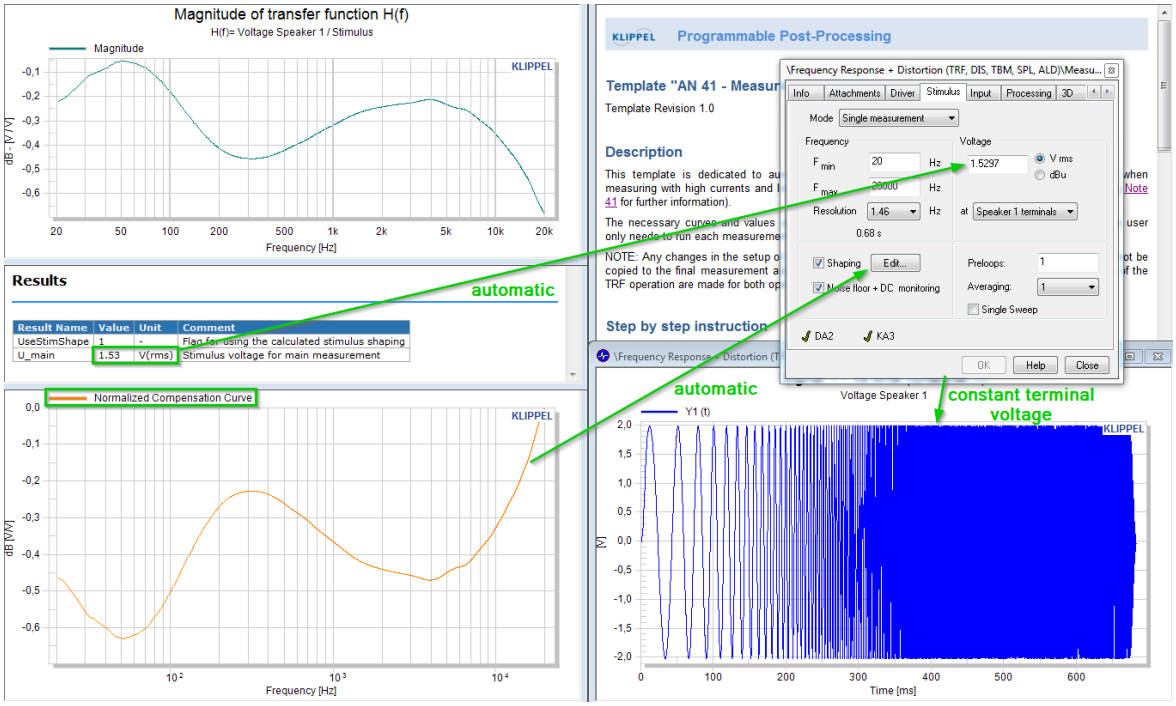
Measurement at defined terminal voltage AN 41

Application Note to the KLIPPEL ANALYZER SYSTEM (Document Revision 1.1)

When a loudspeaker is operated via power amplifier, cables, connectors and clips the voltage at the terminals is not identical with 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.

This Application Note is a step by step description how to do such a measurement by using the template Voltage Compensation.



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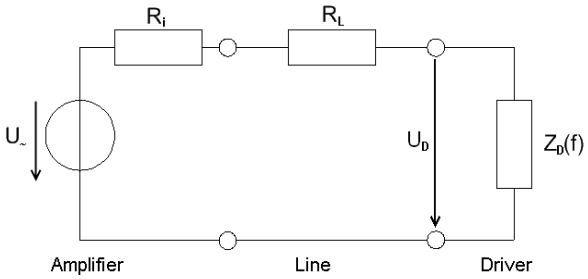


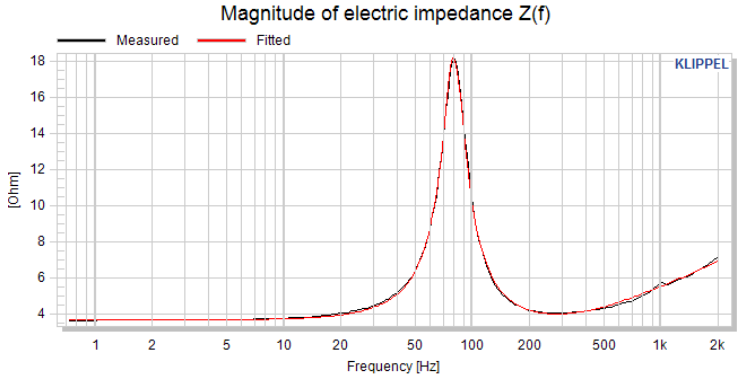
Equivalent circuit explaining voltage variation at the terminals

The generation of nonlinear distortion in loudspeakers depends on the amplitude of the electrical stimulus (usually the voltage U_D at the terminals).

The voltage at the terminals depend on

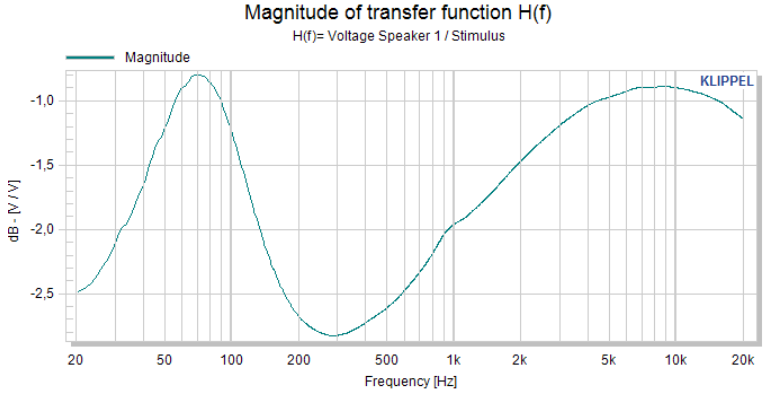
- Transfer function between input and output of the power amplifier. Conventional ac-coupled amplifiers have a high-pass characteristic.
- Output impedance of the power amplifier.
- Resistance of the cables, connectors and clips used between amplifier and DUT.
- Electrical input impedance of the DUT.

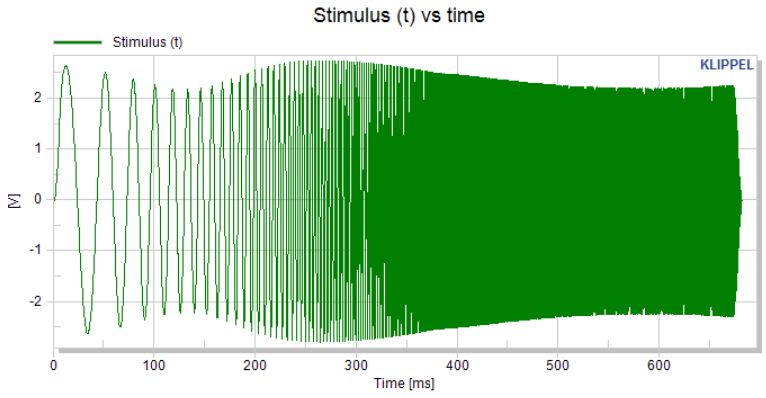
Electrical input impedance



The electrical input impedance Z_D varies significantly versus frequency due to the effect of the mechanical resonance and 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).

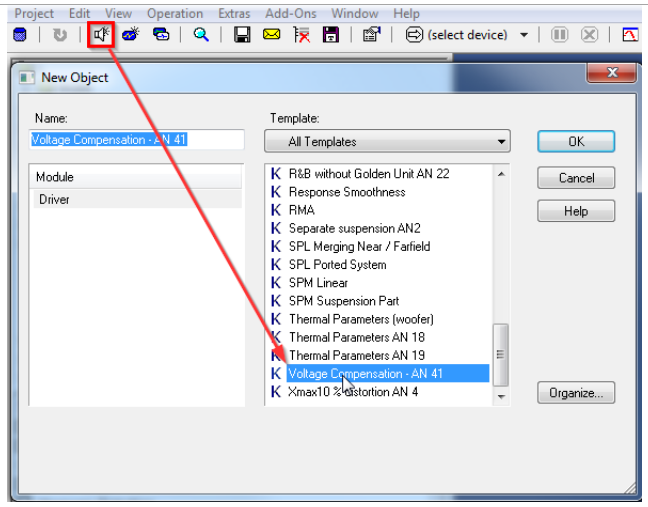
Voltage error



	The KLIPPEL Analyzer hardware provides a four wire sensing technique to measure the precise voltage at the 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.
Shaping the Stimulus	The Klippel dB-Lab 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 using a SHAPING of the stimulus. This shaping curve has to be given as a two-column matrix with the frequency in the first and its according amplitude in dB in the second column. The shape of the stimulus spectrum is adjusted to the shape of the imported curve. For security reasons the shaping curve is automatically scaled before applying it to the stimulus. The scaling limits the maximal shaping factor to 0 dB, i.e. the stimulus amplitude will never be increased so that the provided voltage is maximum of your stimulus (e.g. in the picture below we have 3V(rms) which will just be obtained at the end of the sweep). To compensate for attenuation and to realize the desired target voltage at the speaker terminals the amplitude of the stimulus has to be increased. 

2 Requirements

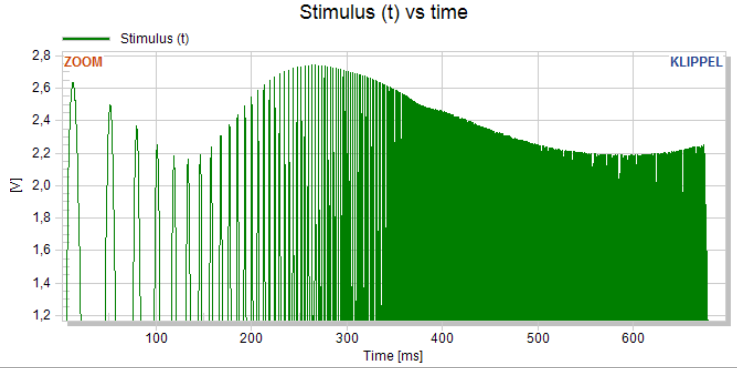
Hardware / Software	To perform TRF measurements with voltage compensation the following hardware and software is required:	
	Hardware:	○ Klippel Analyzer hardware (DA1, DA2 or KA3)
	Software:	○ dB-Lab 210 or higher *
	Licenses	○ TRF – Transfer Function (Standard or Pro) ○ PPP – Programmable Post-Processing
Preparation	• Create a new object in dB-Lab and select the Voltage Compensation template to start the analysis	

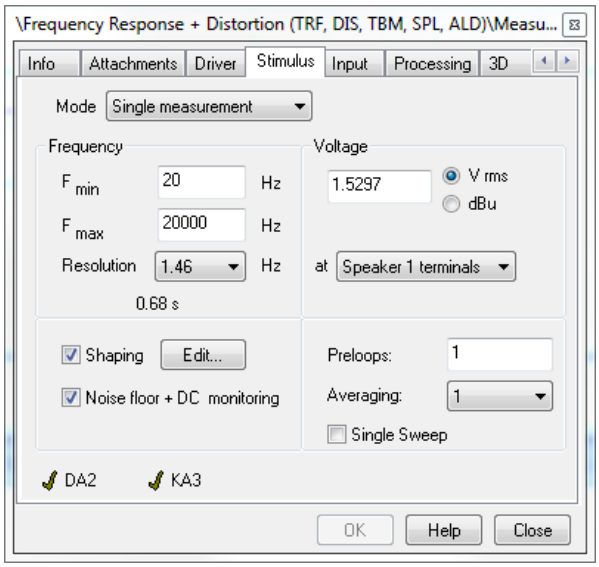
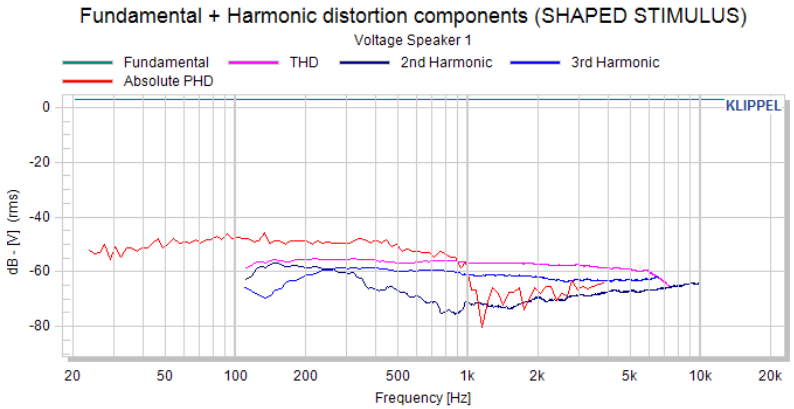


- Enter the sensitivity of the microphone in property page *Input* for the *3 TRF main measurement* or use a pistonphone to calibrate the microphone (using TRF operation template *TRF mic calibration for IN1*).

* for dB-Lab version ≤ 206 there is an older version of this AN available

3 Procedure

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 function is needed afterwards to generate the shaping function. **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. Specify your maximum bandwidth (F_{min} and F_{max}) you will also use for the main measurement. Run the *TRF pre measurement*. 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. 

	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.
3 Main Measurement	**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*!
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 of the transfer response of the amplifier, output impedance of the amplifier, cable length and electrical input impedance of the loudspeaker.

4 More Information

Software	User Manual of the *KLIPPEL R&D System*

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