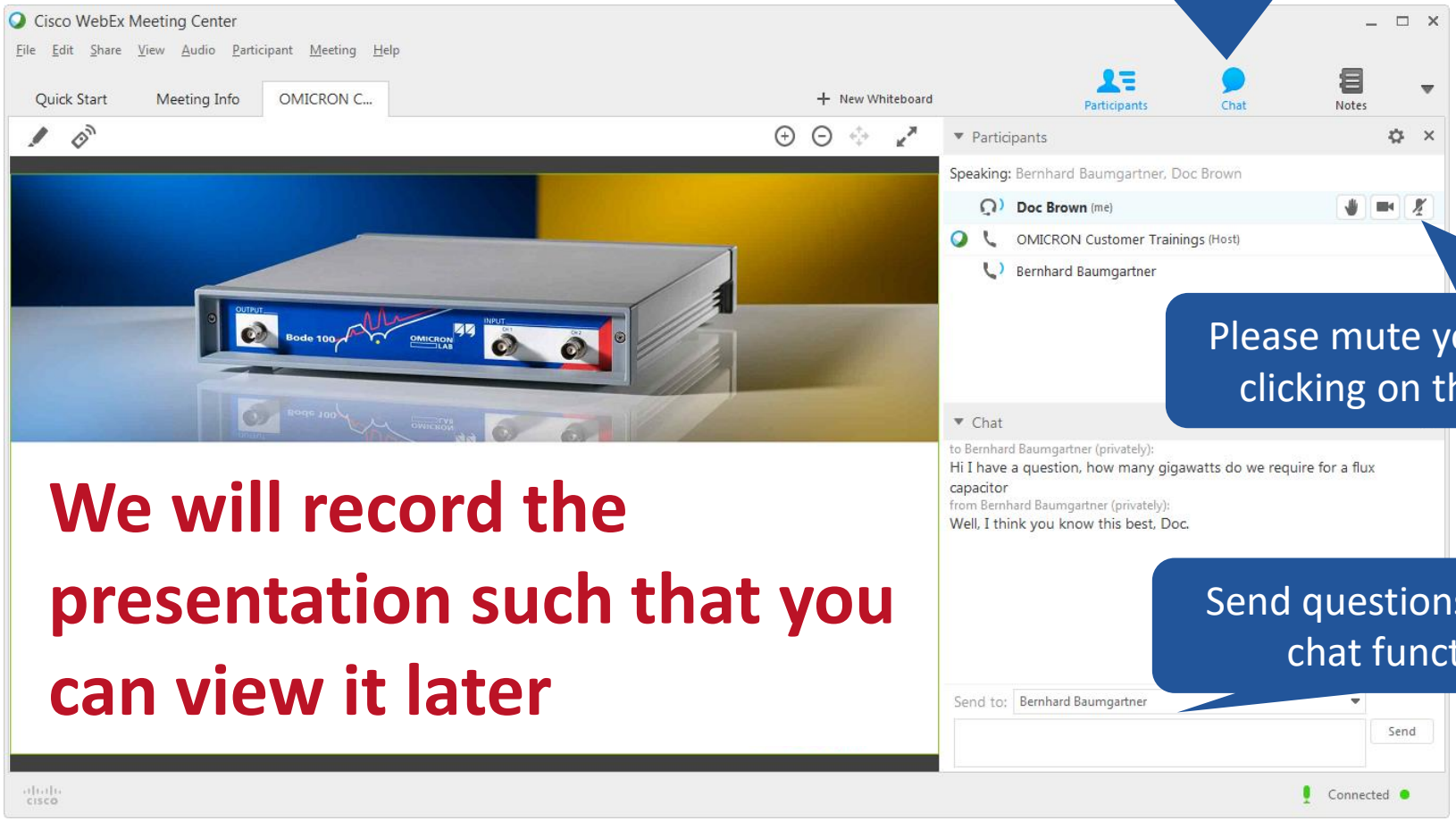
Characterization of High-end Audio Components

OMICRON Lab Webinar Nov. 2015

OMICRON LAB

Webinar Hints

Activate the chat function



We will record the presentation such that you can view it later

Please mute yourself by clicking on this icon!

Send questions via the chat function

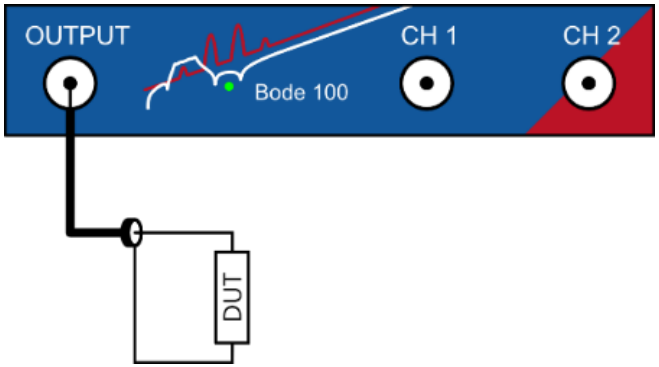
Agenda

- Audio Amplifier
  - In- & output impedance measurement
  - How to measure the amplifier gain
- Audio crossover
  - Measure the transfer function
  - Compare measurement with simulation
- Loudspeaker
  - Impedance of tweeter and mid-range

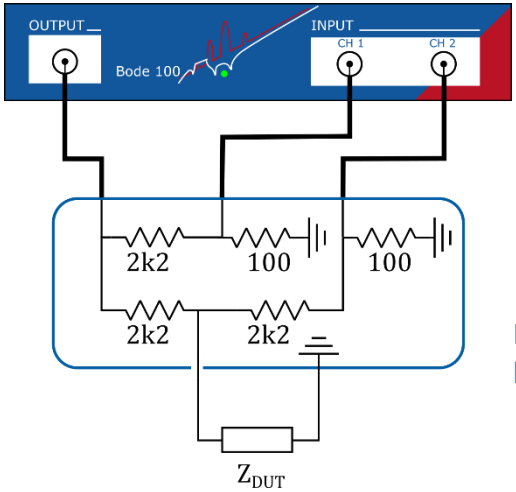
Input Impedance

- Input impedance is typically measured at 1 kHz
- It needs to be >10 kΩ (typ. 10 kΩ - 100 kΩ)

Possible measurement setups:



Recommended for 0.5 Ω – 10 kΩ



High impedance bridge

Recommended up to a few MΩ

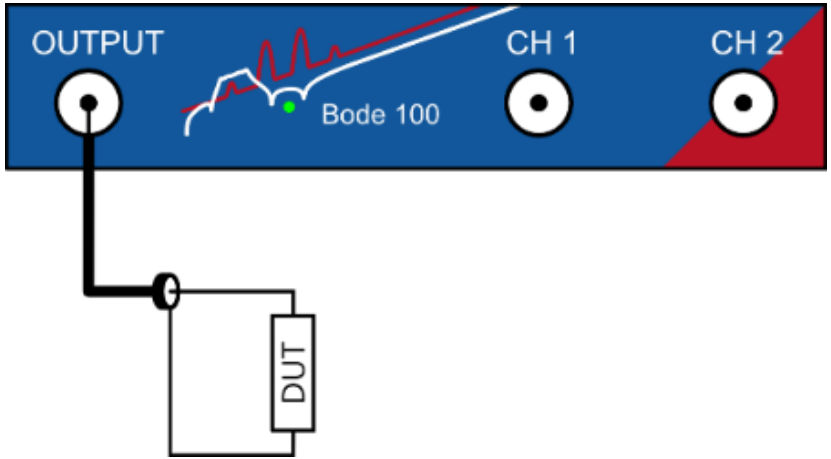
Output Impedance

- Attention:
  Markings on amplifier
  - Recommended speaker impedance
  - Not the amplifier output impedance

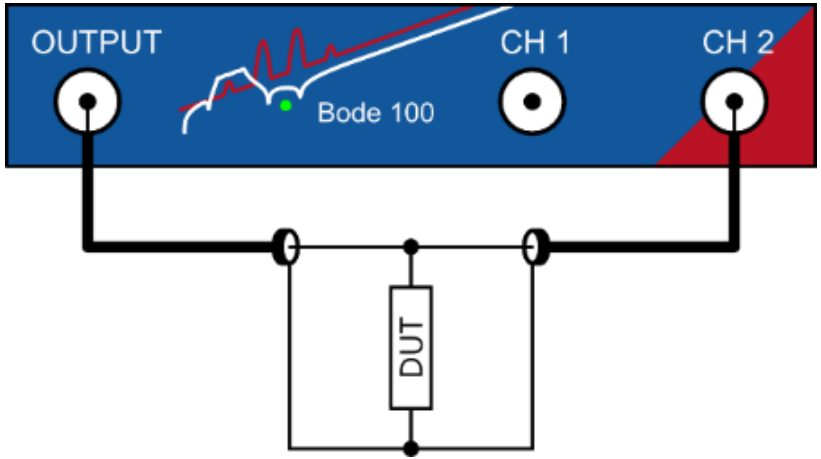
- Typical amplifier output impedance @ 1kHz: 20 mΩ to 2 Ω
  - No impedance matching ($Z_{Amp} = Z_{Speaker}$)
  - Just bridging ($Z_{Amp} << Z_{speaker}$)

Output Impedance

Possible measurement setups:



Recommended from 0.5 Ω – 10 kΩ



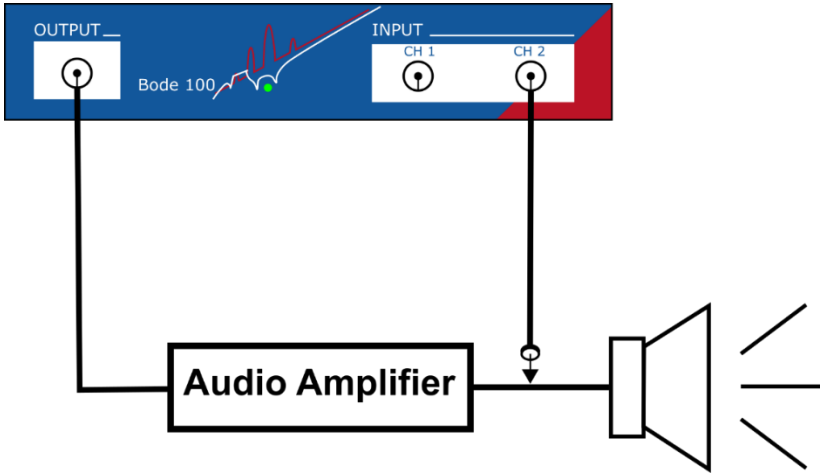
Recommended from 1 mΩ – 10 Ω

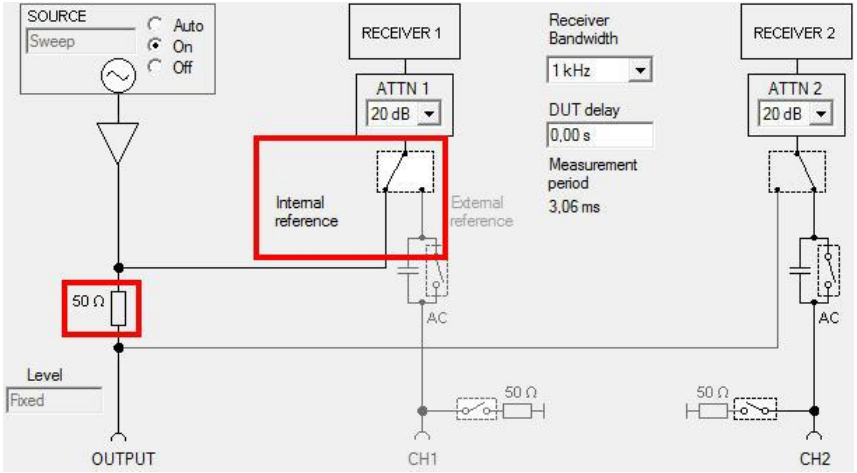
Output of audio amplifier must be **ZERO** during this measurement!

Live Measurements

- Input- & output impedance of an audio amplifier

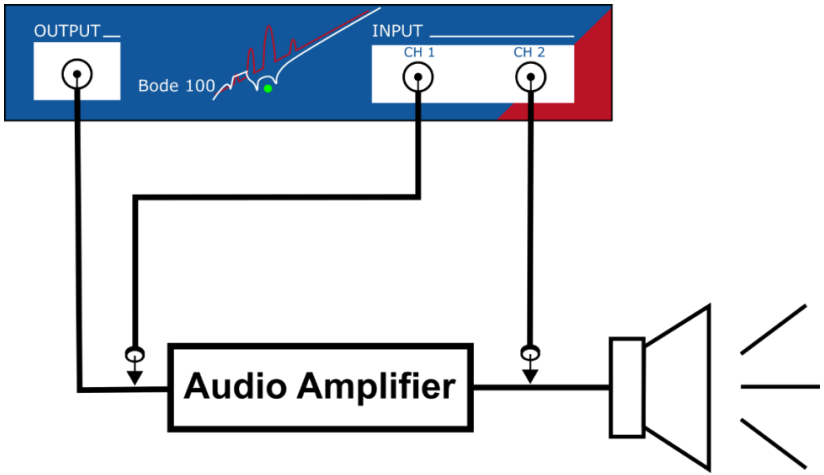
Gain Measurement – Internal Reference

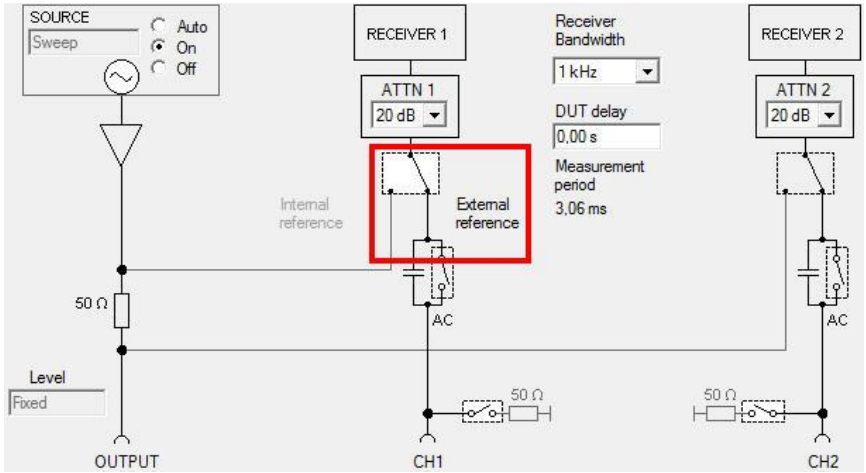




- Internal reference:
  - Internal reference signal is $V_{CH1} = \frac{V_0}{2}$
  - $Z_{outBode100}$= 50 Ω
  - Error introduced since $Z_{inAmp} \neq 50\ \Omega$

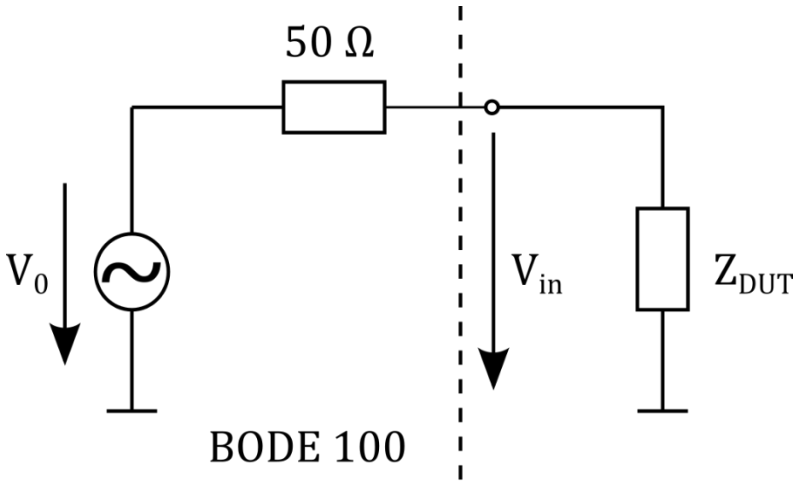
Gain Measurement – External Reference





- External reference:
  - Reference signal measured at amplifier input
  - $V_{CH1} = V_{inAmp}$
  - No error introduced

Error Calculation for internal reference



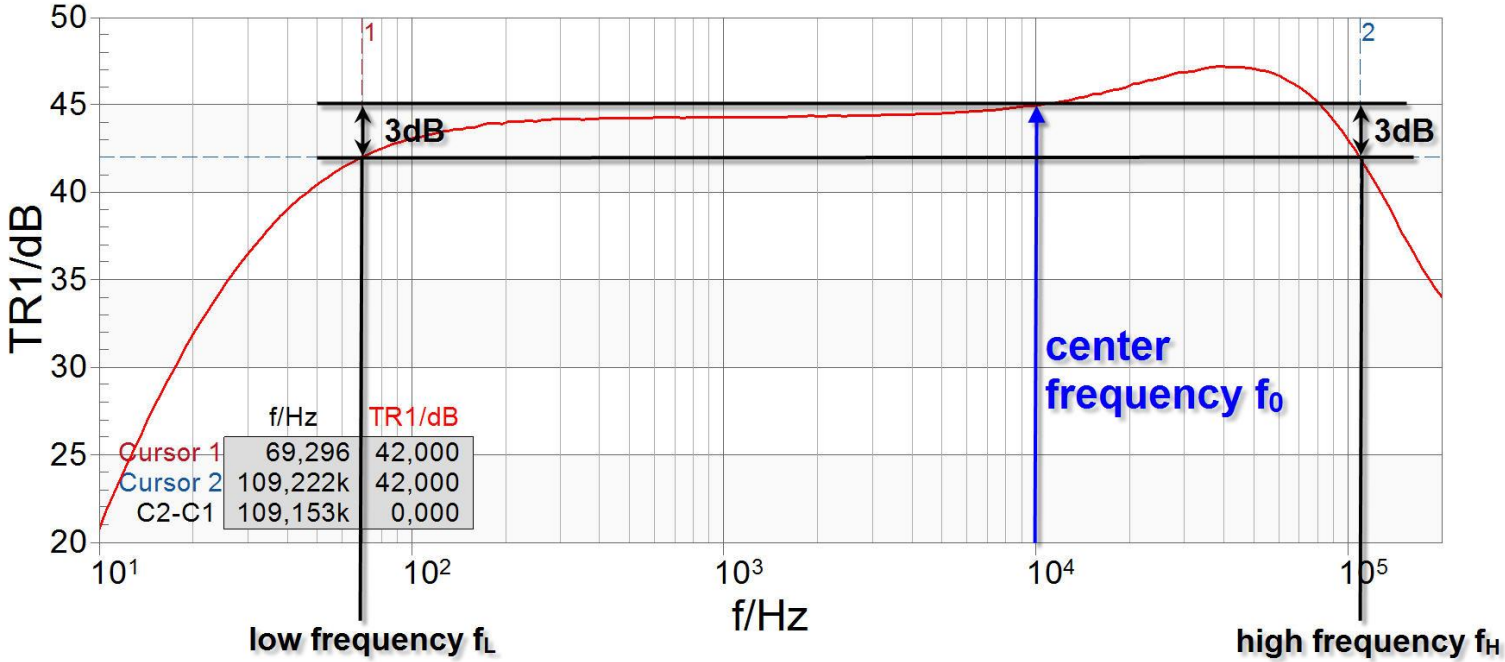
- Internal reference
  - V_{Ref} derived from V_0
  - V_{in}depends on Z_{DUT} (Voltage divider)

$$V_{in} = V_0 \cdot \frac{Z_{DUT}}{Z_{DUT}+50\ \Omega} = V_0 \cdot \frac{10\ k\Omega}{10\ k\Omega+50\ \Omega} = V_0 \cdot 0.995 \rightarrow 0.5\%$$

Introduced error is only 0.5%

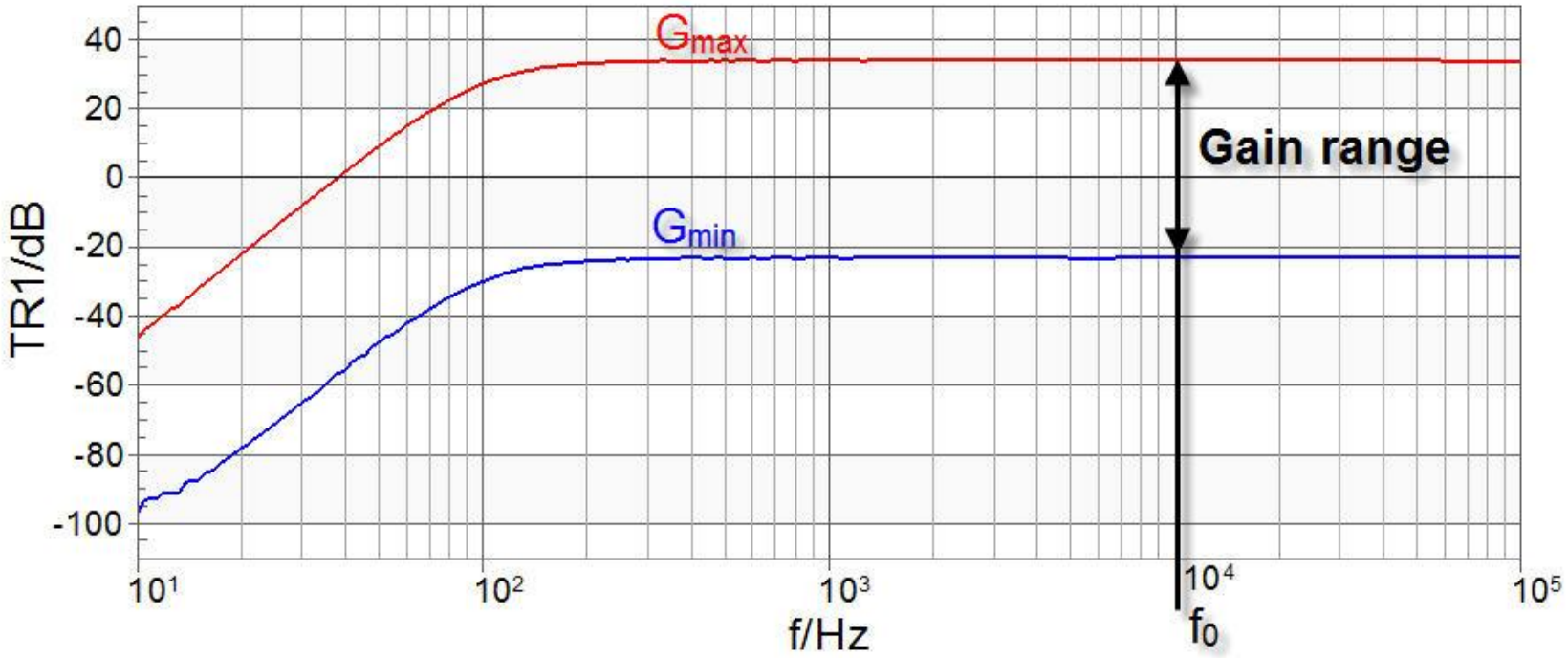
→ Internal reference can be used to measure Gain

3 dB Bandwidth



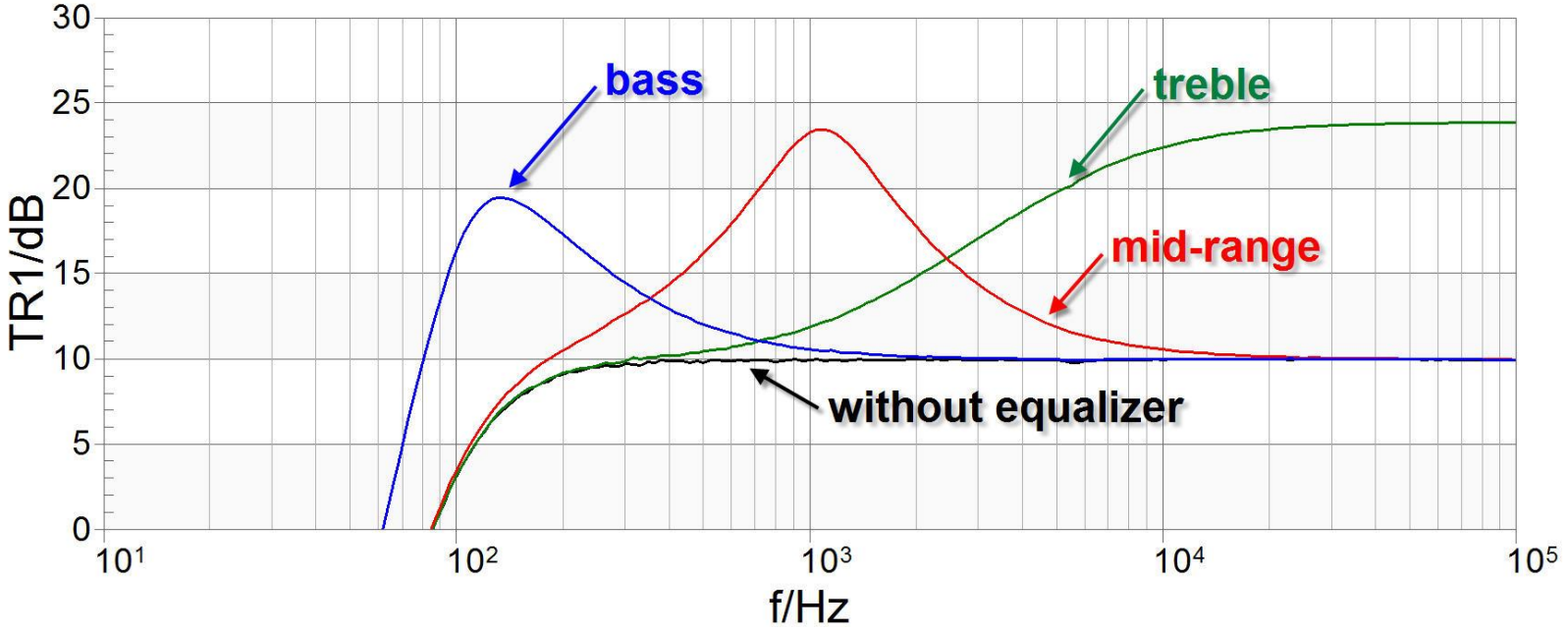
Audible frequencies range from 20 Hz to 20 kHz
→ center frequency f_0 @ 10 kHz chosen

Gain Range of the Audio Amplifier



- Gain range = $G_{max} - G_{min}$
- Measured at f_0

Equalizer Influence

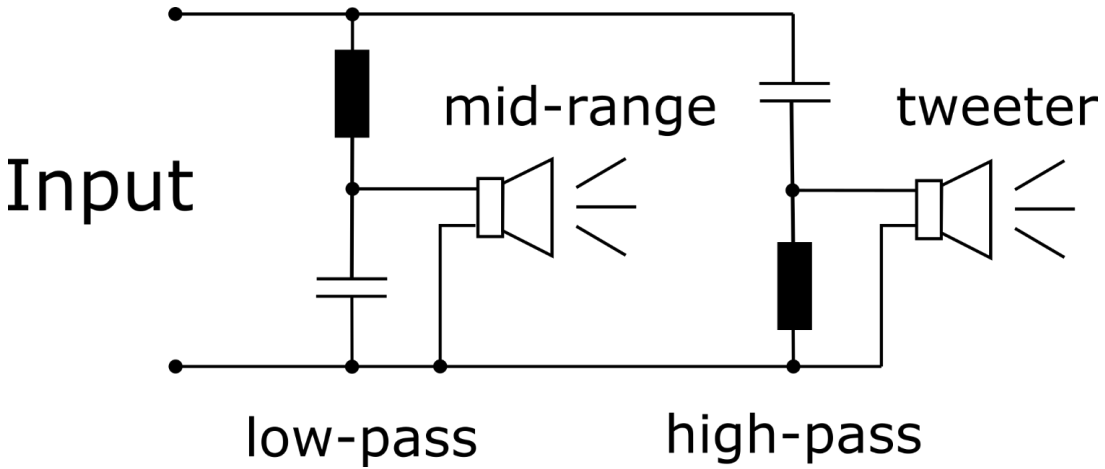


- Measured equalizer has three frequency bands (bass, mid-range and treble)
- Allows amplification or attenuation

Live Measurements

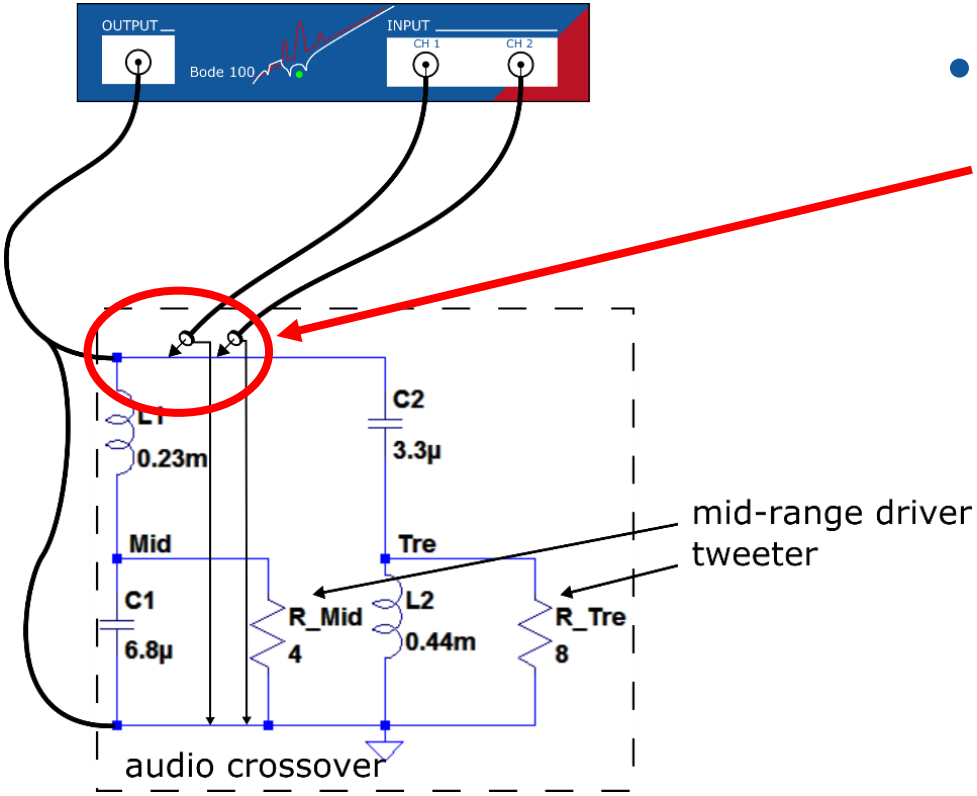
- 3 dB Bandwidth
- Gain range
- Equalizer influence

Audio Crossover



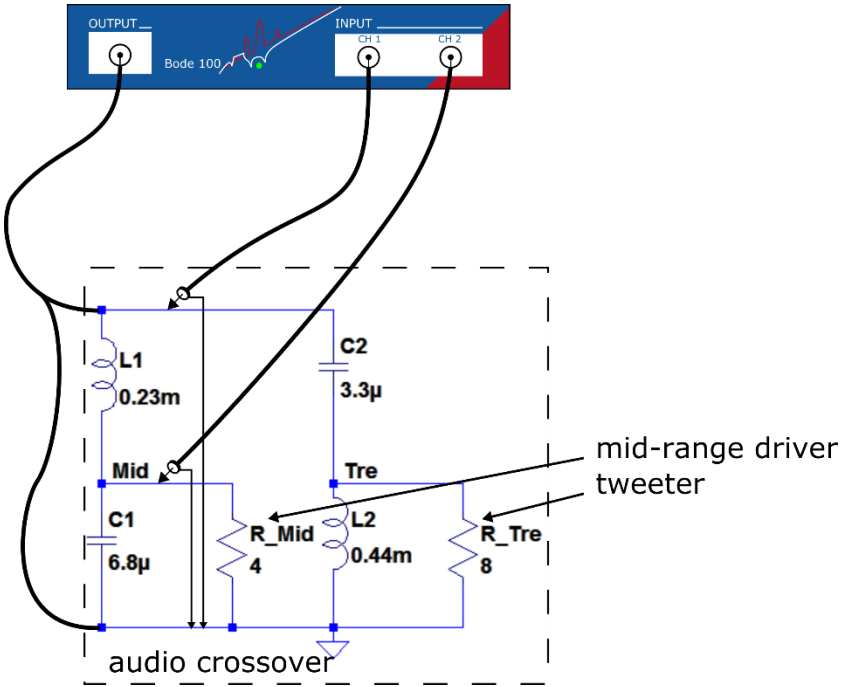
- Simple combination of a LC-low and LC-high pass
- Low frequencies go to the mid range driver
- High frequencies go to the tweeter

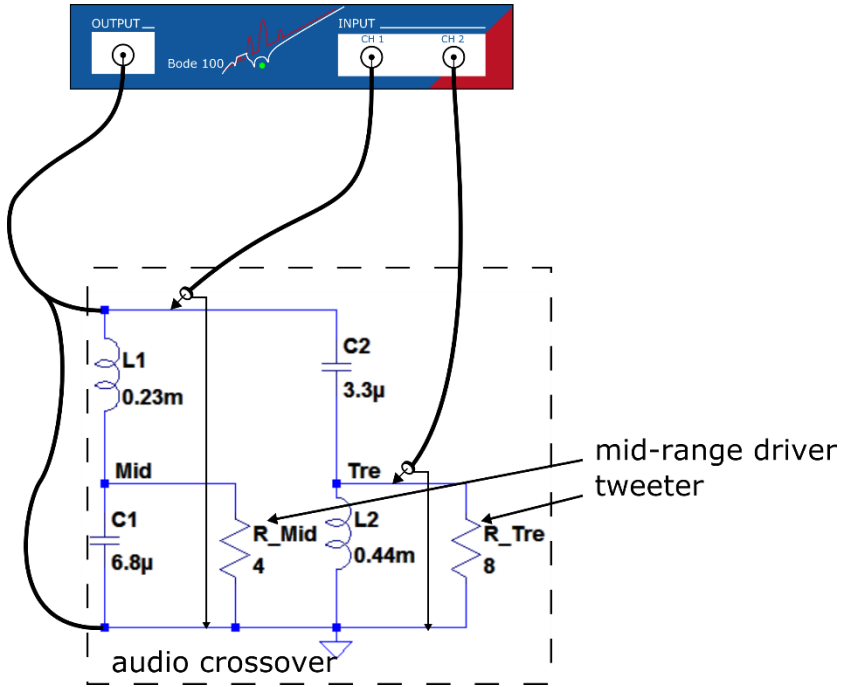
Calibration Setup



- THRU Calibration
  - Both channels connected to same point on DUT
  - Need to receive signal from Bode 100

Measurement Setup





$$G_{mid} = \frac{CH2}{CH1} = \frac{output\ midrange}{input\ crossover}$$

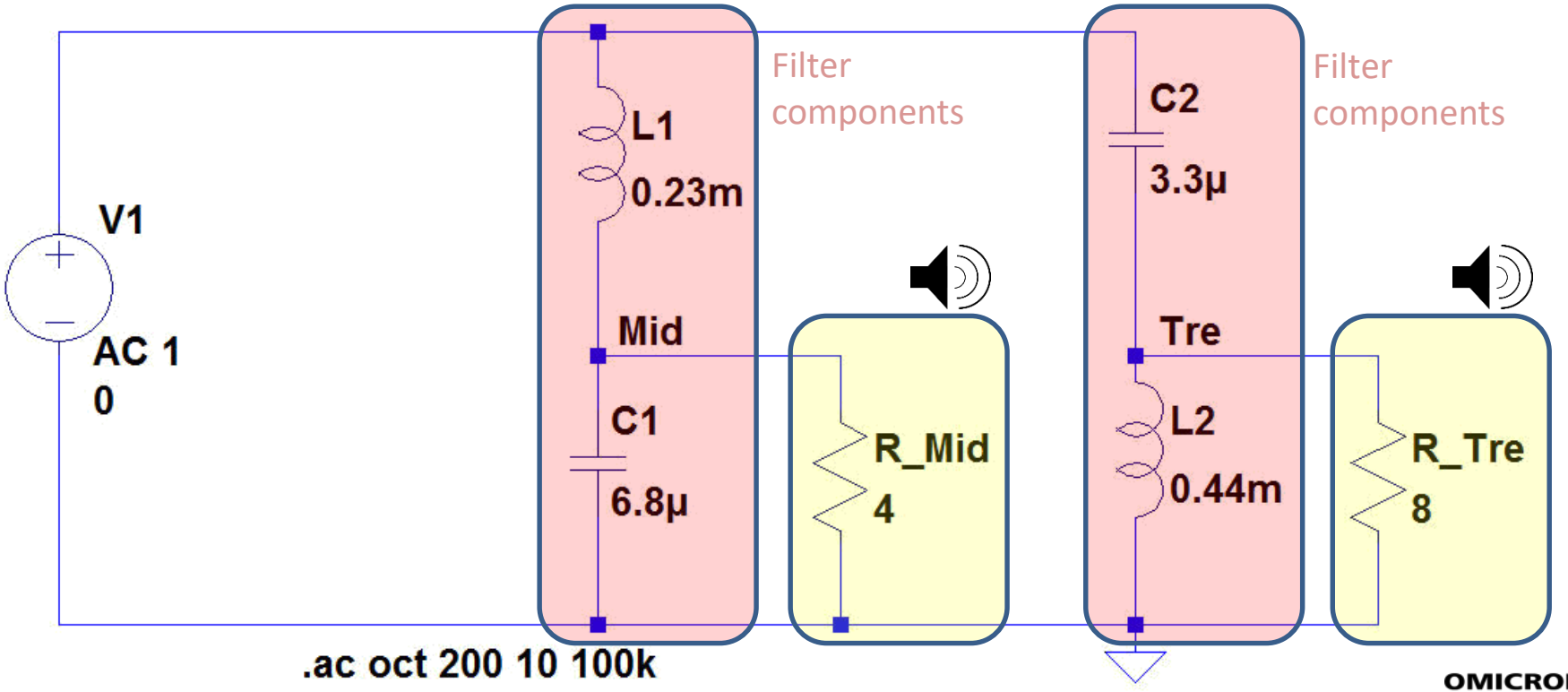
$$G_{tweet} = \frac{CH2}{CH1} = \frac{output\ tweeter}{input\ crossover}$$

Live Measurements

- Each path and overall transfer function of an audio crossover

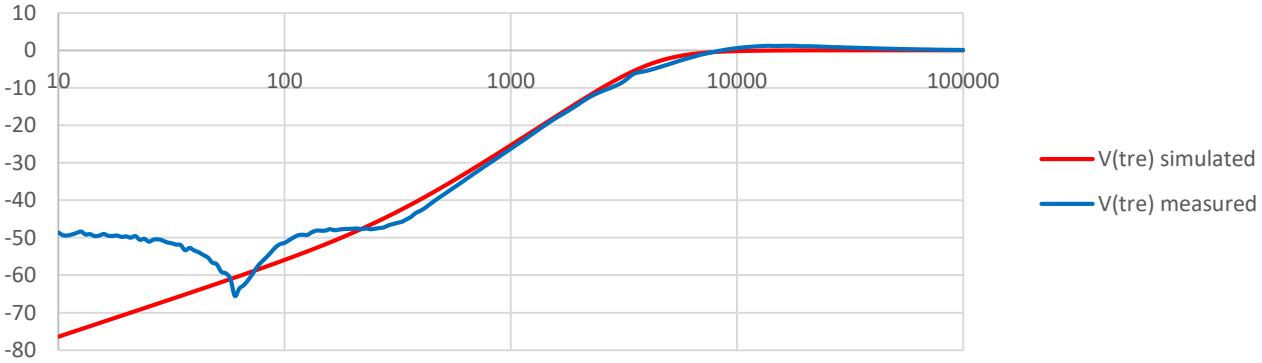
LTspice Simulation

Schematic that is used in the simulation:

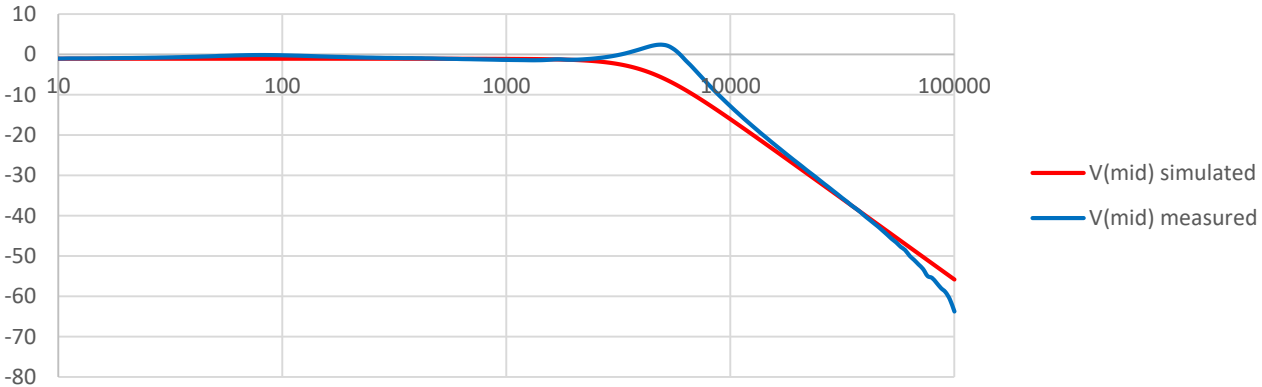


Comparison of Measurement & Simulation

Treble path

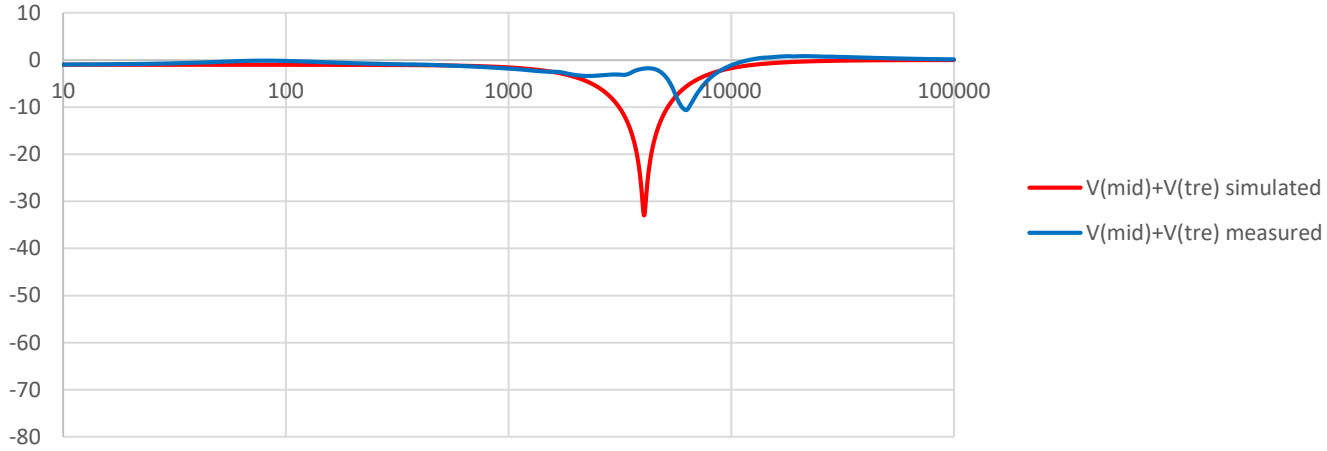


Mid-range driver path



Comparison of Measurement & Simulation

Treble + mid-range path

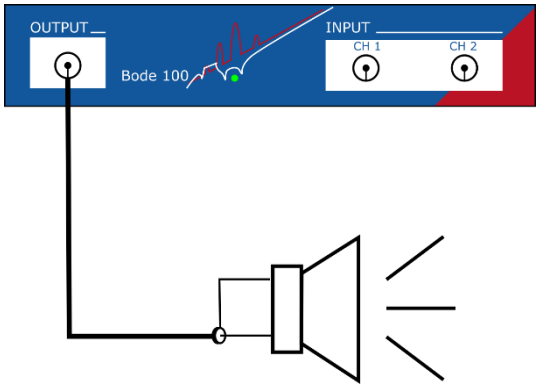


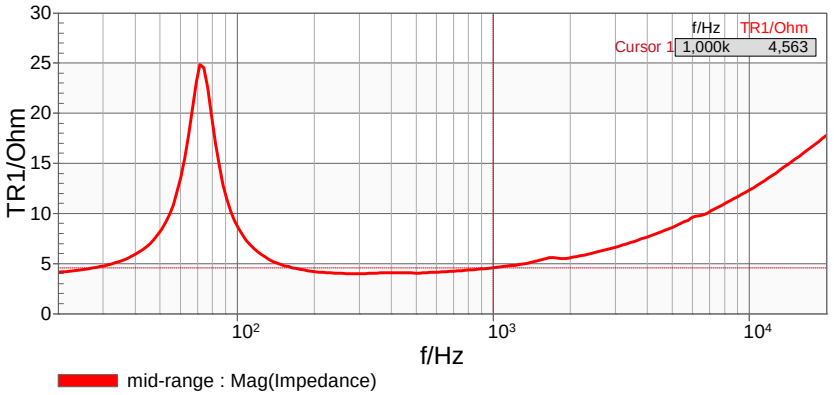
Comparison diagrams created in Excel® by copying the trace data from the BAS and exporting the LTspice simulation curves.

see Application Note:
Audio Systems Measurement – Loudspeaker Audio Crossover Measurements
https://www.omicron-lab.com/application-notes/

Loudspeaker Impedance

- Loudspeaker impedance typically between 2 and 16 Ω
- Specified impedance usually measured at 1 kHz
- Loudspeaker impedance changes over frequency



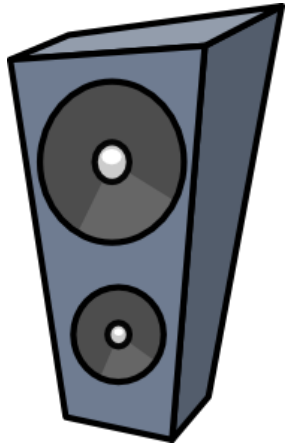


Live Measurements

- Loudspeaker impedance

Summary

- Bode 100 has perfect frequency domain
- Allows to assess the quality
- Measure gain & impedances with one device
- Easy way to measure transfer function of filters
- Visualize speaker nonlinearities



Feel free to ask questions via the chat function...

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You can contact us at: info@omicron-lab.com

Thank you for your attention!