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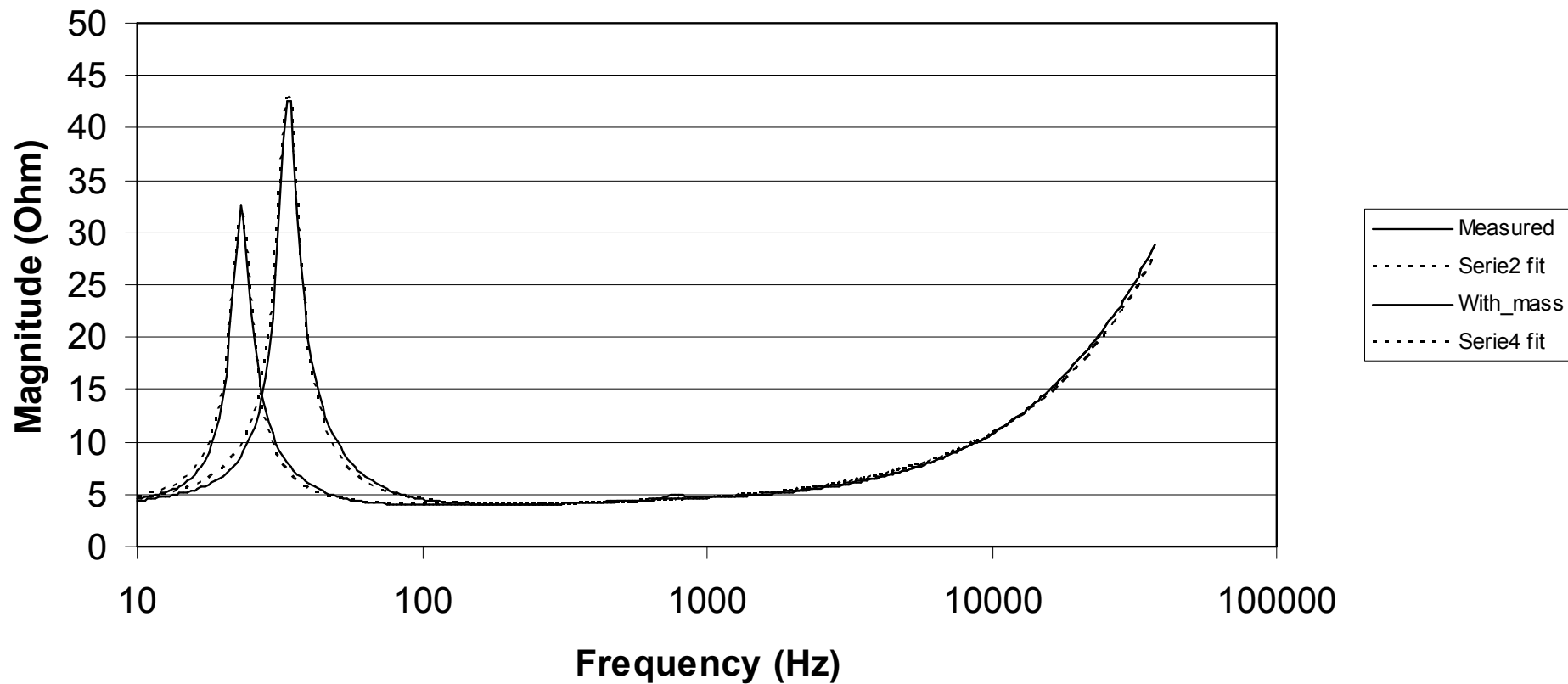
# **Losses in Loudspeaker Enclosures**

Claus Futtrup



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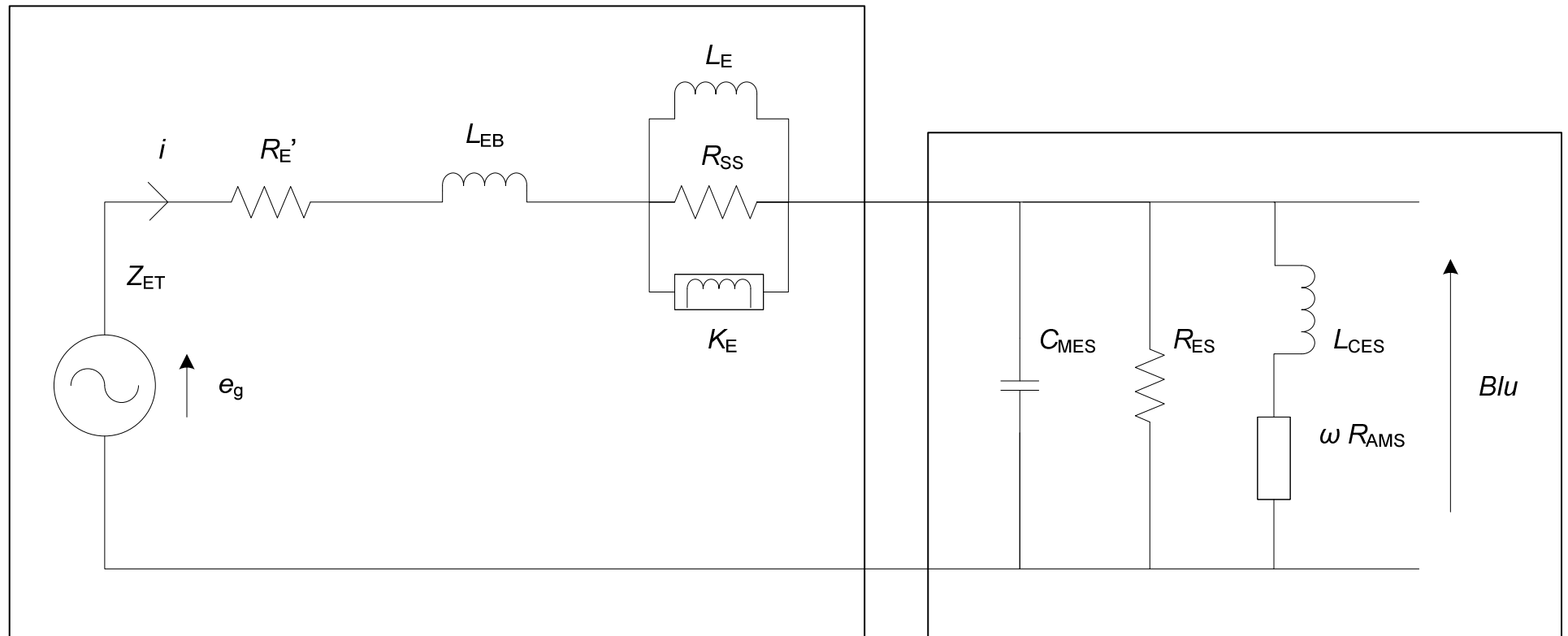
## **Zres – free air, without / with added mass**





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## Transducer model with FDD ( $R_{AMS}$ )



$Z_E$

$Z_{EM}$   
**SCANSPEAK**



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## **R. Small on Qp, Ql and Qa - conclusions**

Qp – between 50 and 100

Qa – typically 100 or more

Ql – between 5 and 20

Link to paper ([PDF](#)) page 5

Quote: The last result is surprising, because the enclosure tested well built and appeared to be leak free...

Quote: ... leads to the conclusion that the measured leakage in apparently leak-free systems is not an error of measurement but an indication that the actual losses in the system enclosure is not constant with frequency...



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## R. Small, Graph with $Q_p$ , $Q_l$ and $Q_a$

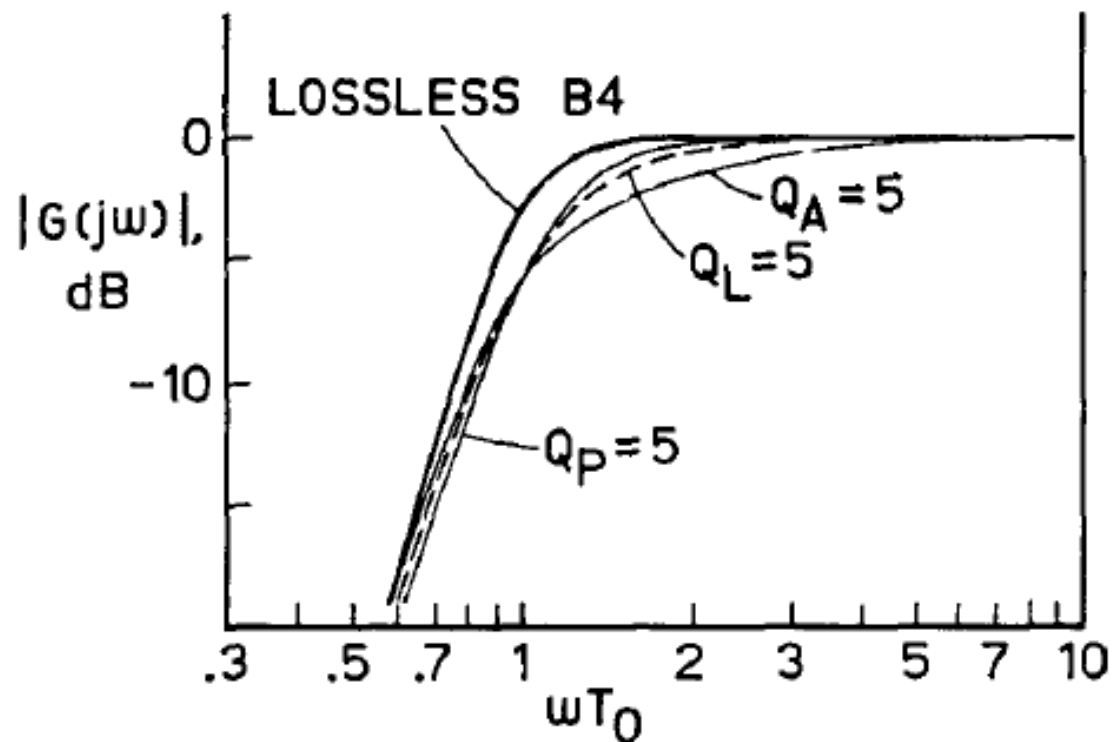
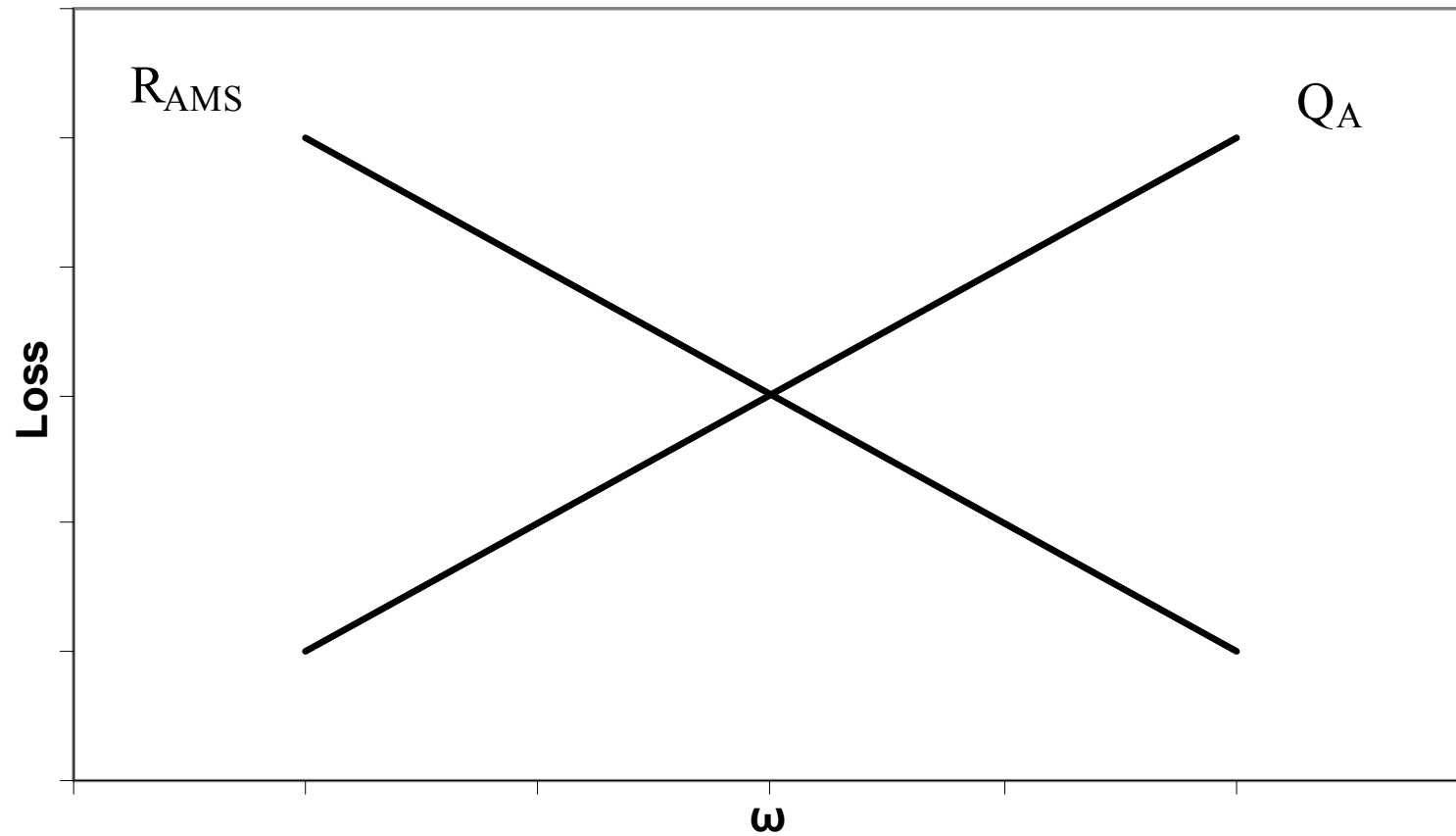


Fig. 4. Effects of enclosure-circuit losses on response of a lossless B4-aligned vented-box loudspeaker system (from simulator).



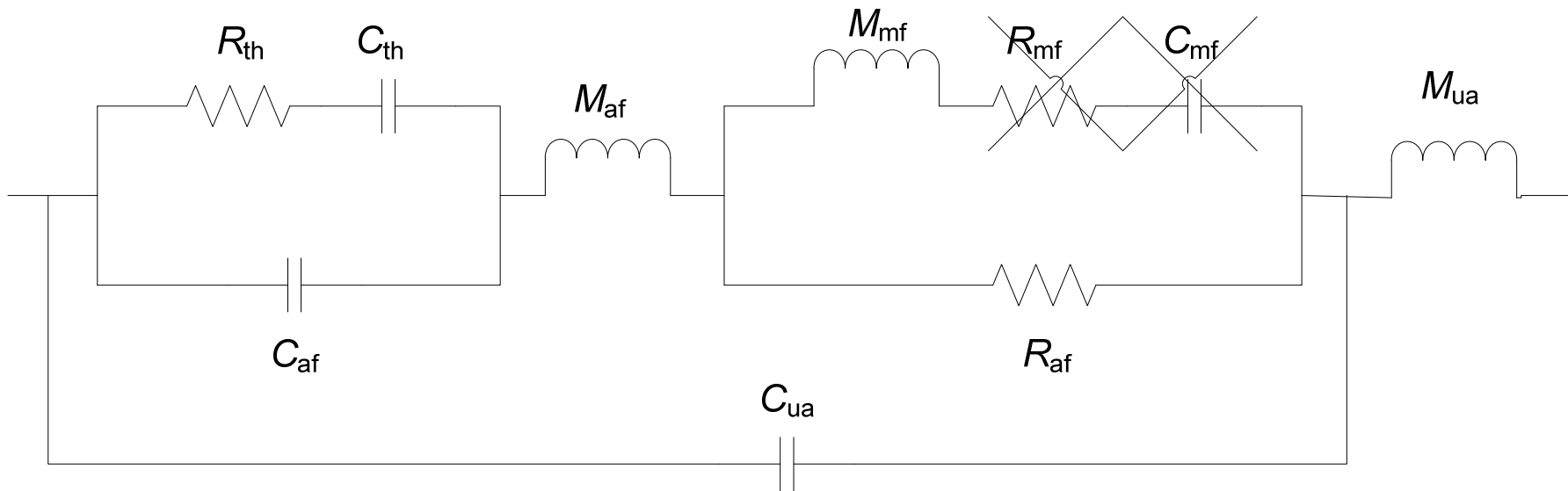
## Losses, $QI = 7$ : A mix of $Q_A$ and Rams





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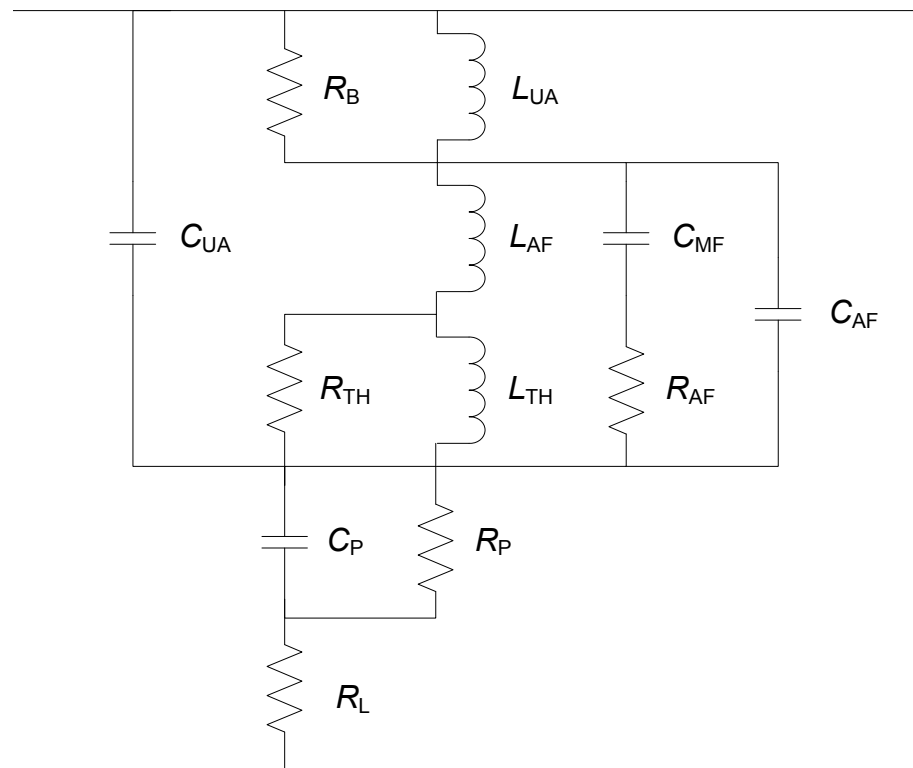
## Model of damping material





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## Electrical equivalent, with $R_b$

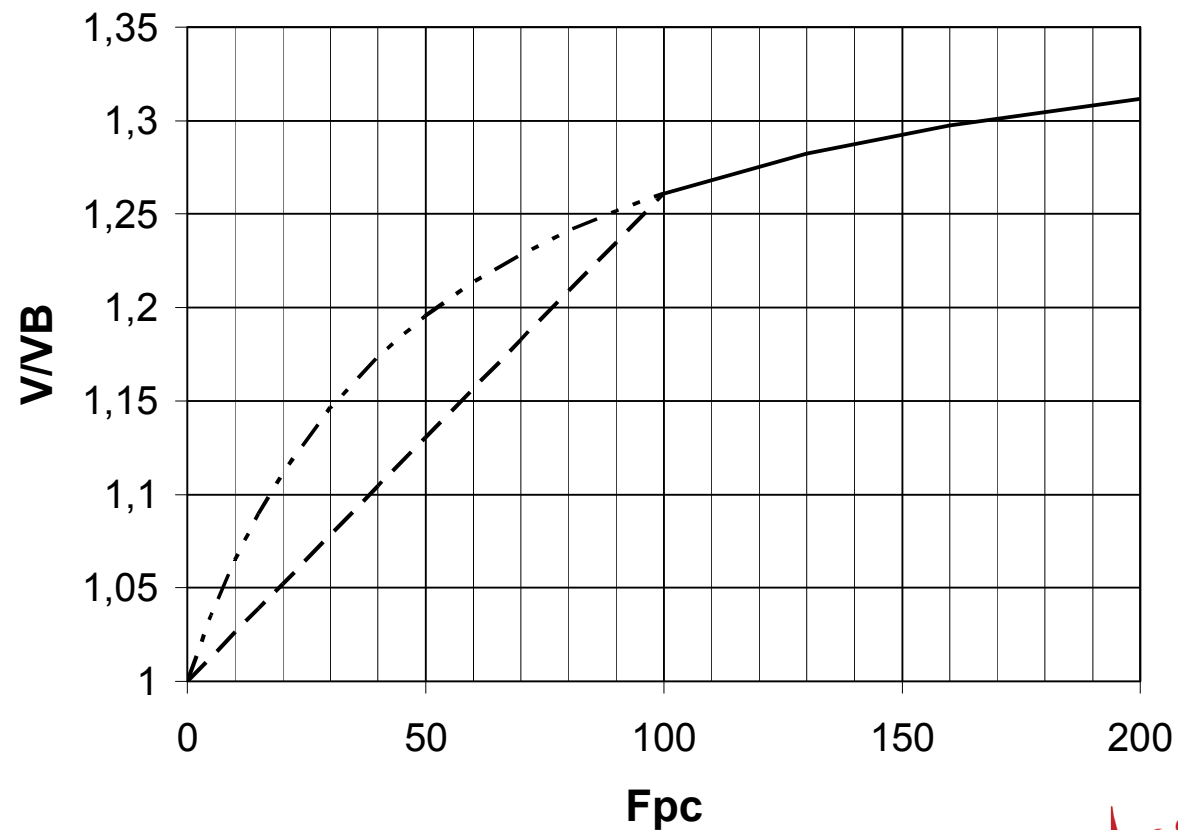






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## Volume expansion graph





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## **Mechanical model, Tarnow**

$$\begin{aligned} R_f = \lambda &= R_{cr}^{2/3} \cdot R_{lr}^{1/3} \\ &= \frac{16 \cdot \eta}{d_f^2} \cdot \frac{f}{0,806 \cdot LN(1/f) - 0,929 + 1,26 \cdot f} \end{aligned}$$



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## **Test box**

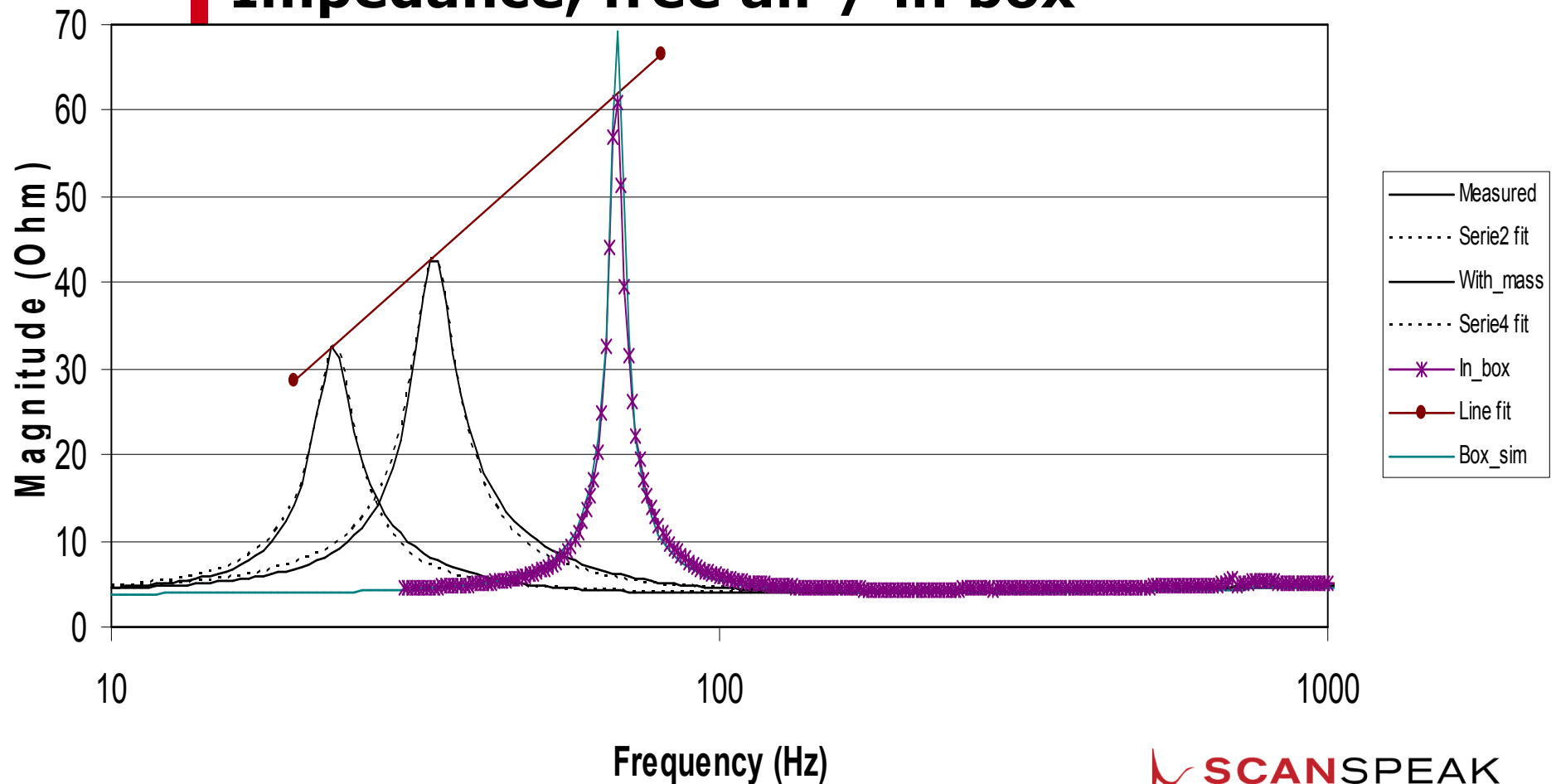
**Essentially lossless**





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## Impedance, free air / in box





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■ Our datasheets contain input to this model.

Download free [software](#) from our web site for box simulation.

<http://www.scan-speak.dk>

- Go to "Products"
- Go to "Toolbox"



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# Thank you Questions?

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