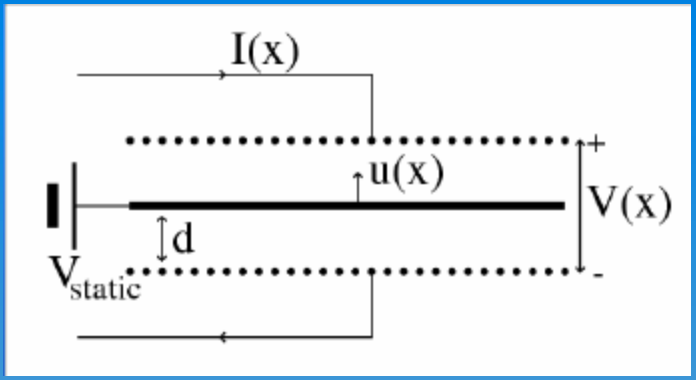
ESL-33:
A segmented line source ESL

Edo Hulsebos

- Physics of the line source ESL
- Segmentation
- Electrical damping
- Step-up transformer
- Construction of the ESL-33

Mechanical equation



Electrostatic force

Diaphragm tension

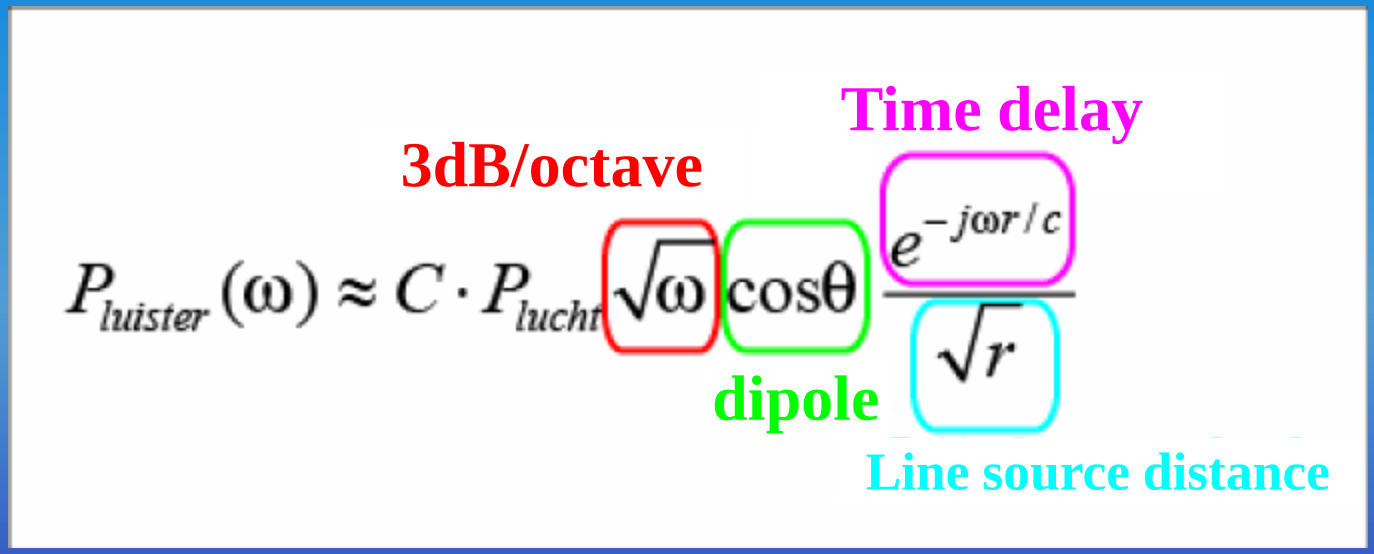
Mechanical damping

$$P_{lucht}(x,t) = -\frac{\varepsilon V_{static}}{d^2}V(x,t) + \frac{2\varepsilon V_{static}^2}{d^3}u(x,t) + s\frac{\partial^2 u}{\partial x^2}(x,t) - \rho\frac{\partial^2 u}{\partial t^2}(x,t) - D\frac{\partial u}{\partial t}(x,t)$$

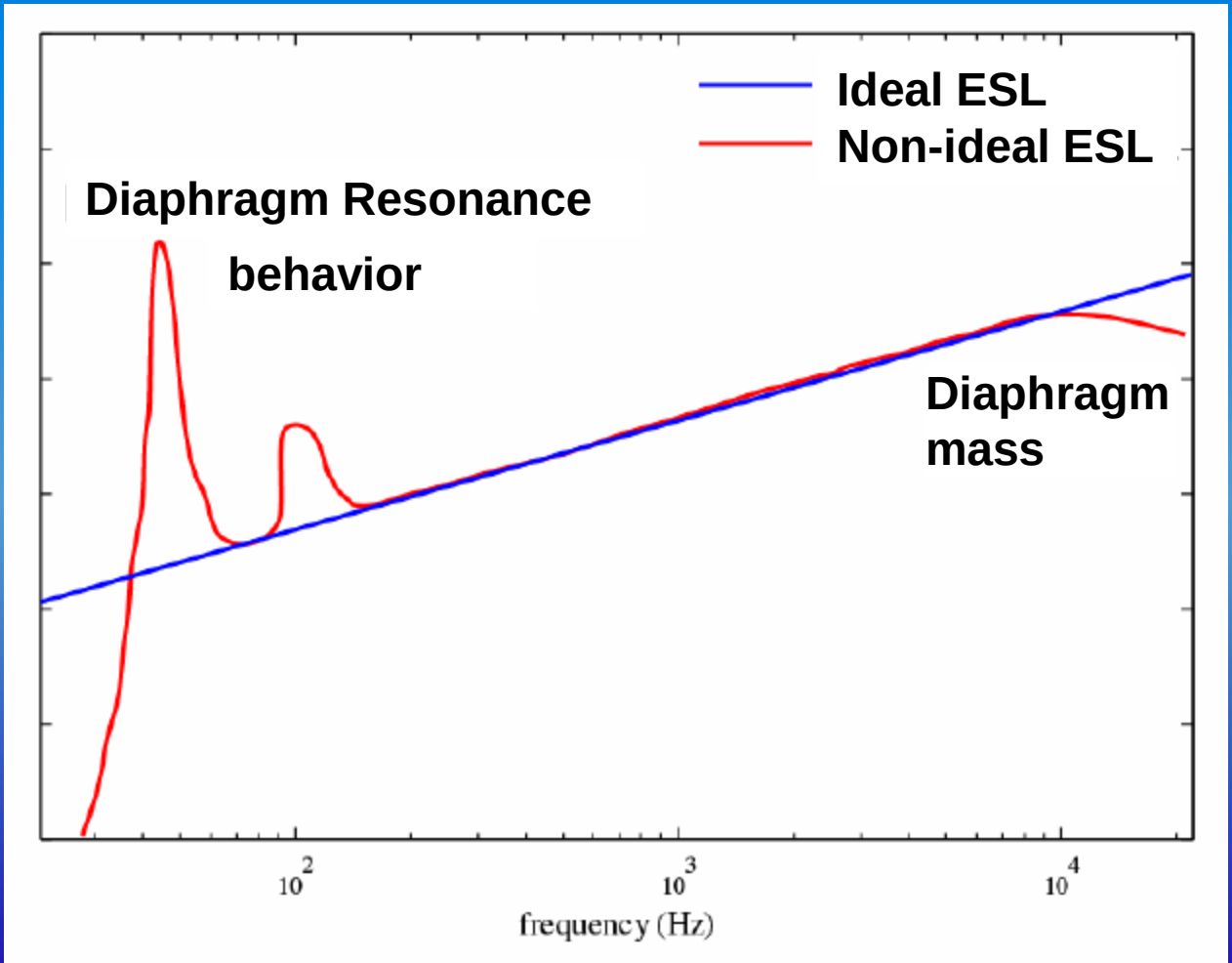
Negative electrostatic compliance

Diaphragm inertia

Acoustic equation



ESL behavior for constant voltage

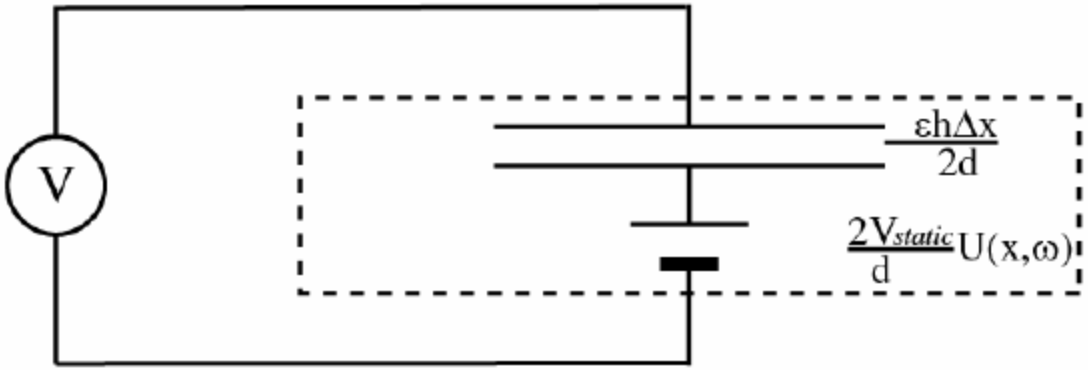


Electrical equation

Stator capacitance

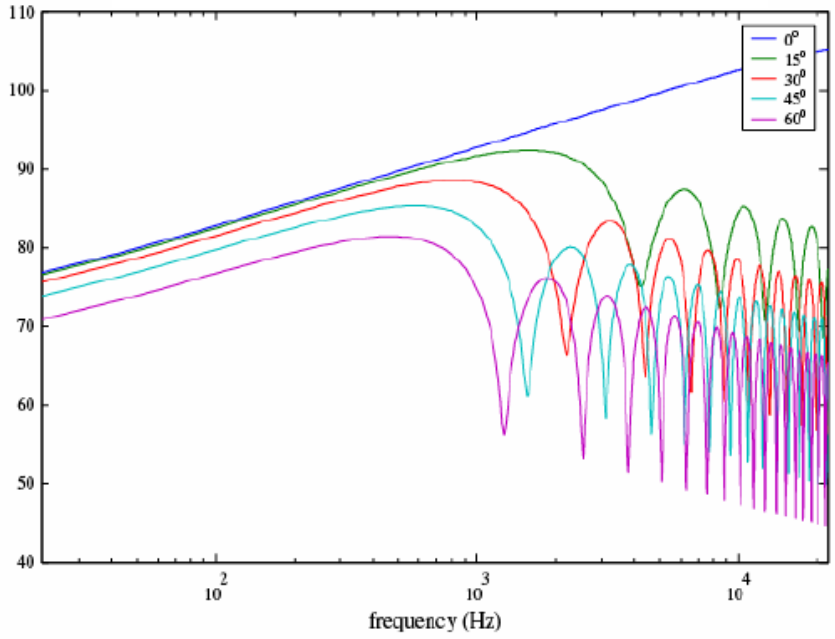
$$I(x,t) = \frac{\varepsilon h}{2d}\left\{\frac{\partial V}{\partial t}(x,t) - \frac{2V_{static}}{d}\frac{\partial u}{\partial t}(x,t)\right\}$$

Microphone operation

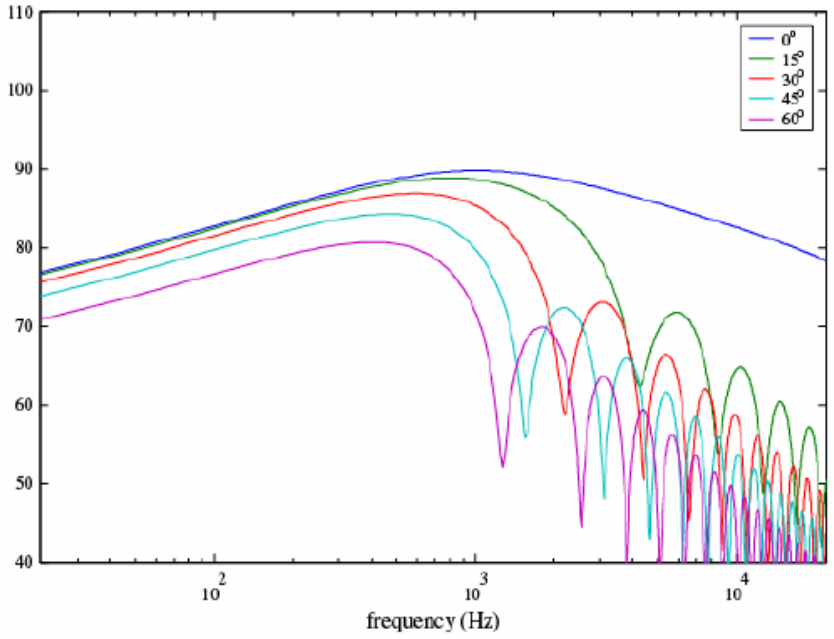


Series resistance

SPL at 3m, constant voltage

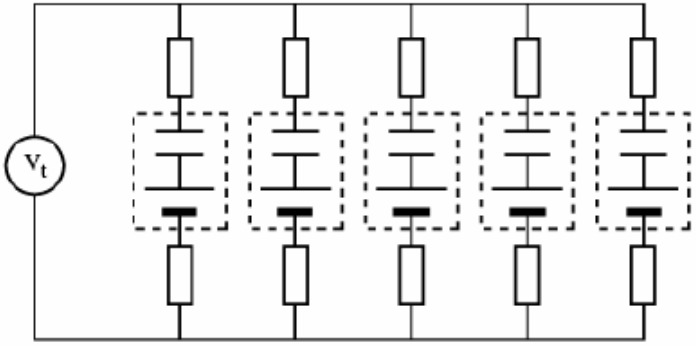


SPL at 3m, with 100kΩ series resistance

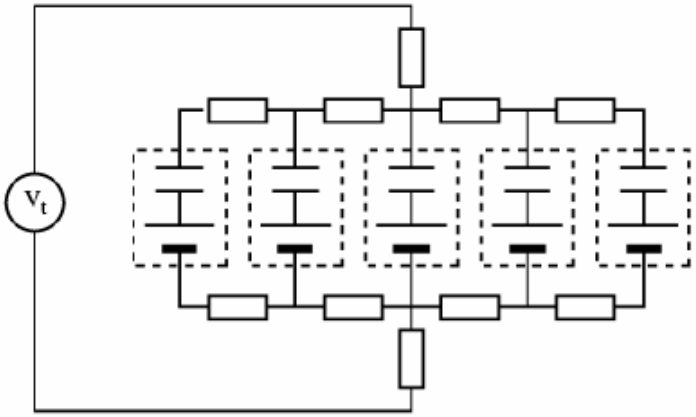


Possible solutions

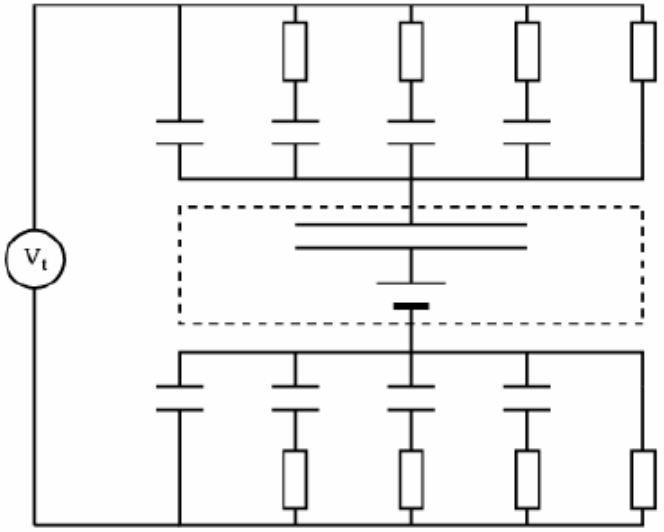
Parallel segmentation



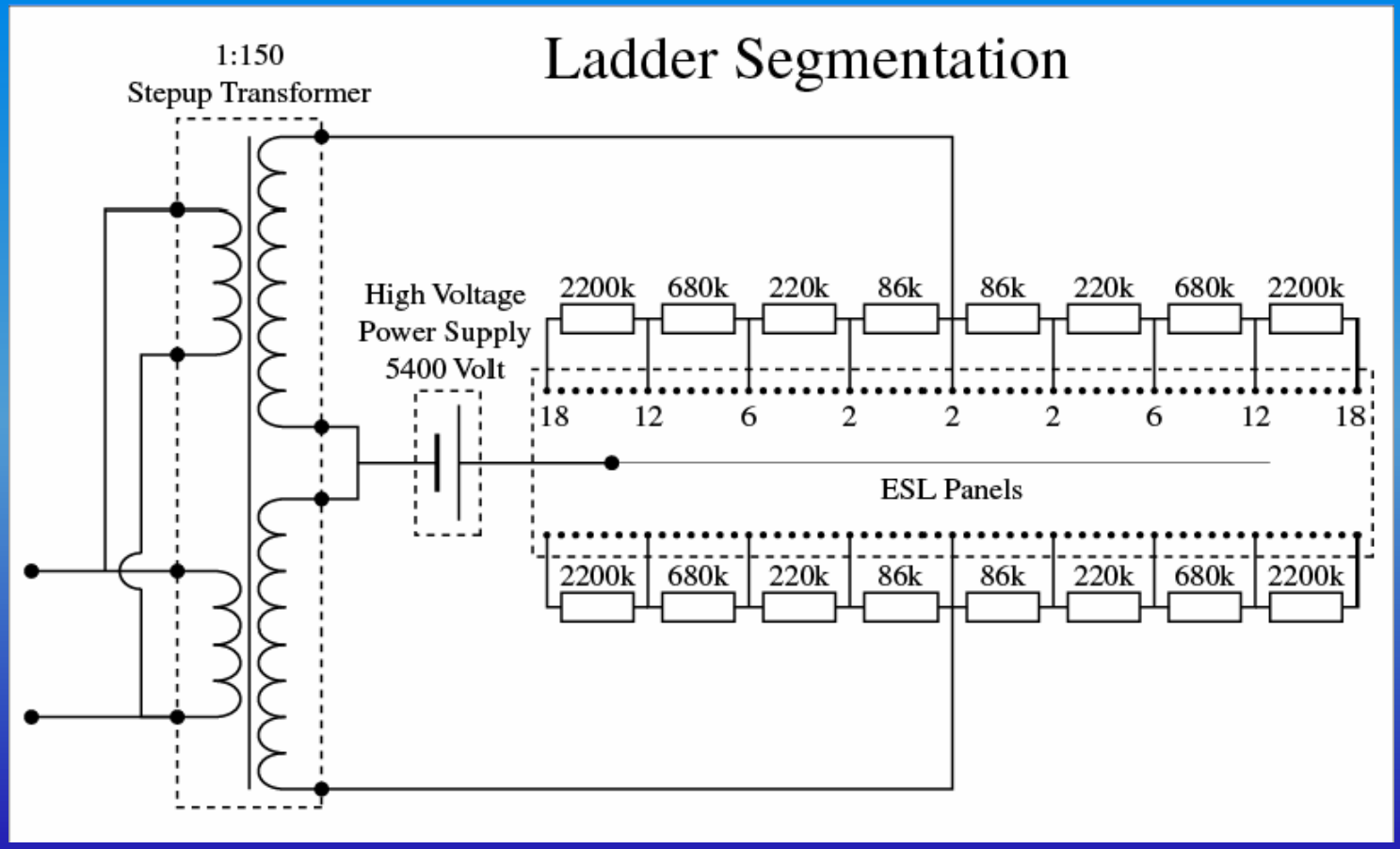
Ladder segmentation



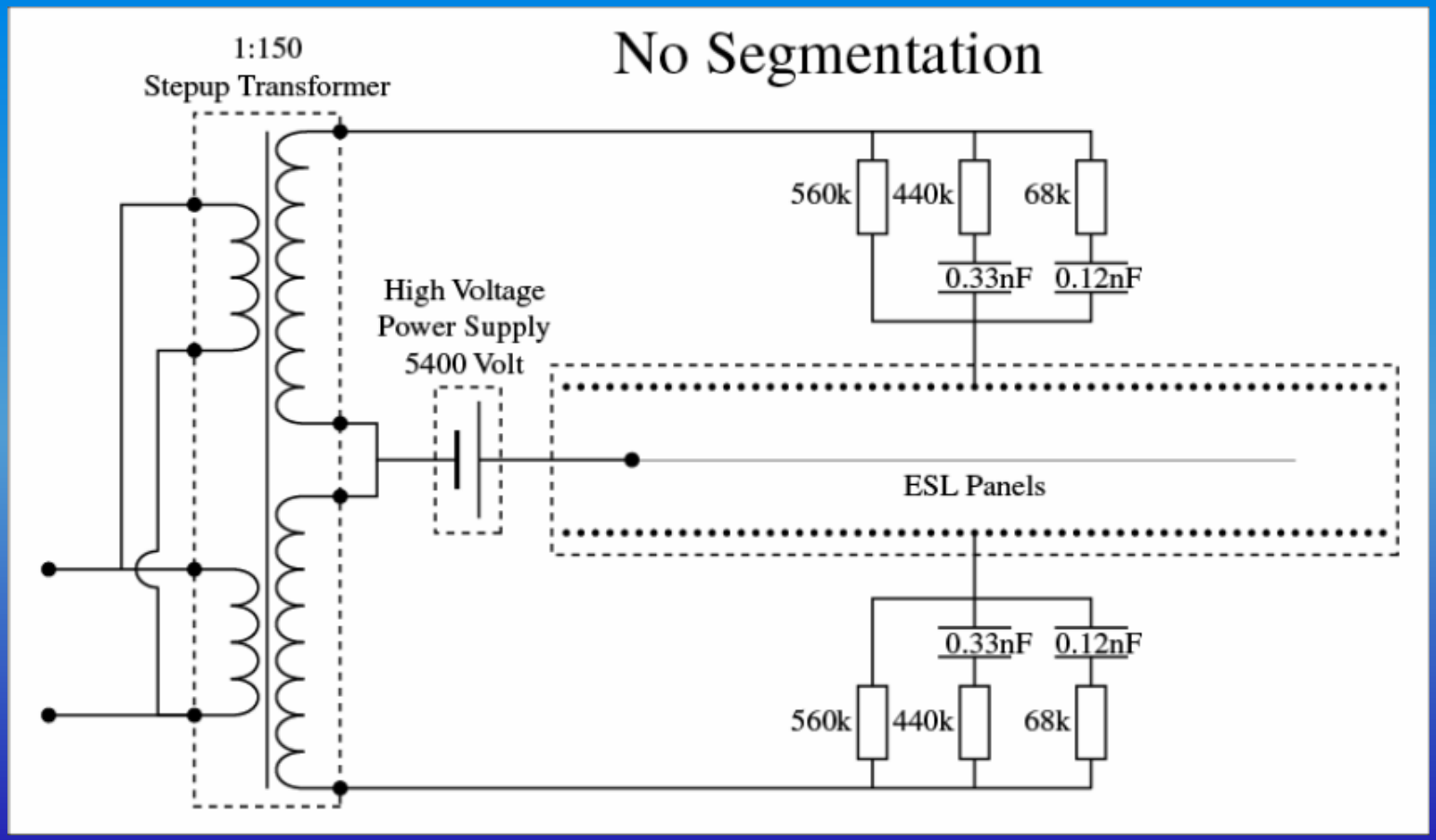
Unsegmented with parallel RC network



Ladder segmentation (ESL-33)

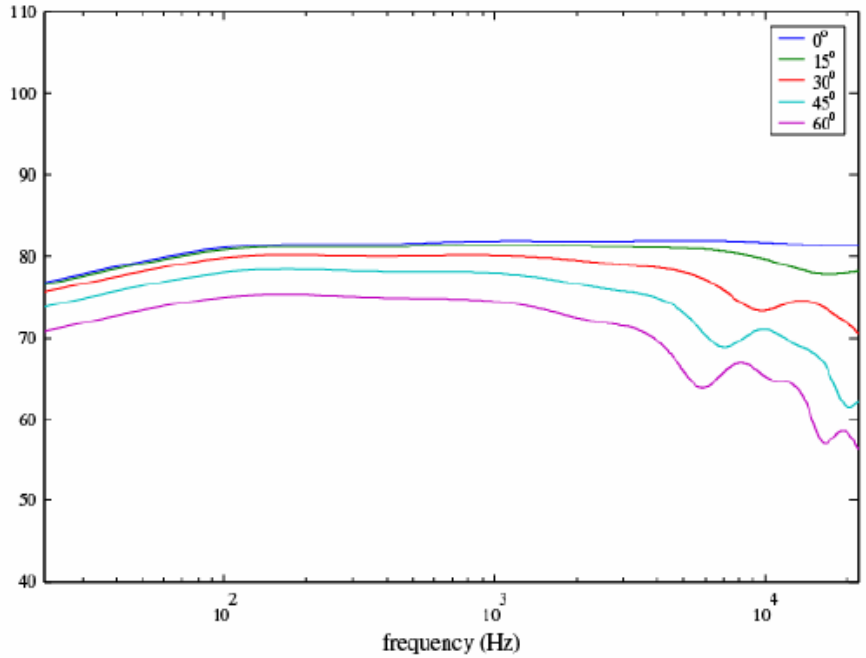


Parallel RC network

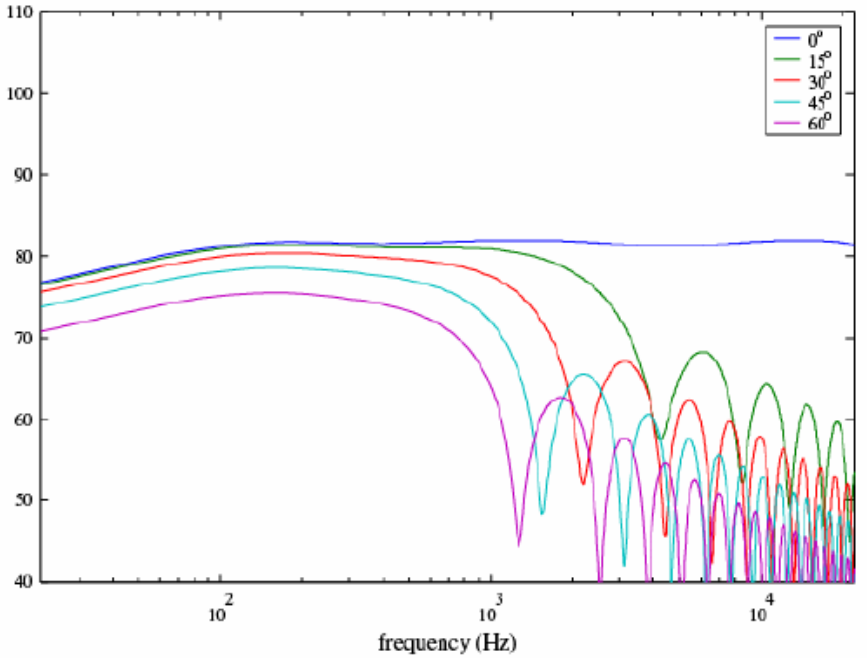


Segmentation simulations

SPL at 3m, ladder network



SPL at 3m, parallel RC network



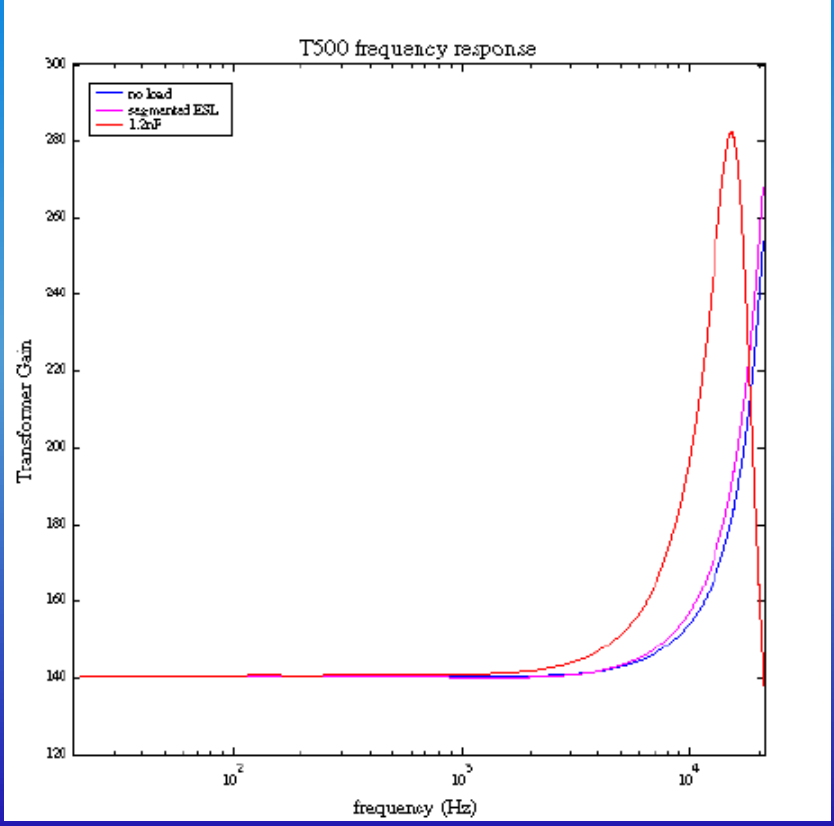
Diaphragm resonances

- Mechanical damping
(speaker grill cloth, wool blanket, etc.)
- Electrical damping by segmentation resistors
- Electrical damping is better at lower resonant frequency, higher resistance, and higher Vstatic

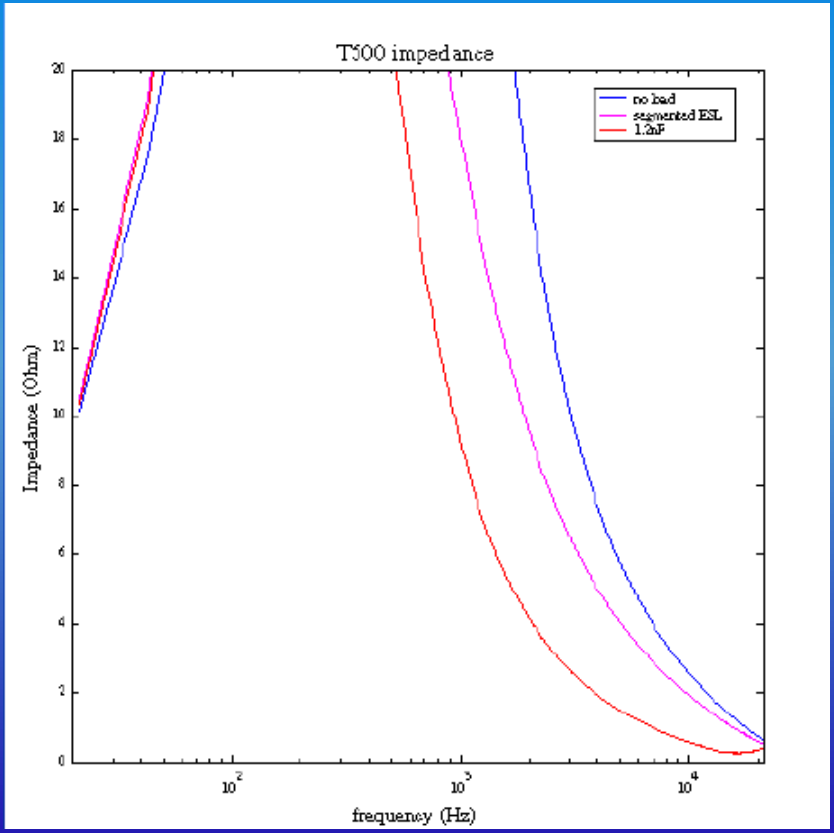
Step-up Transformer

Transformer characteristics

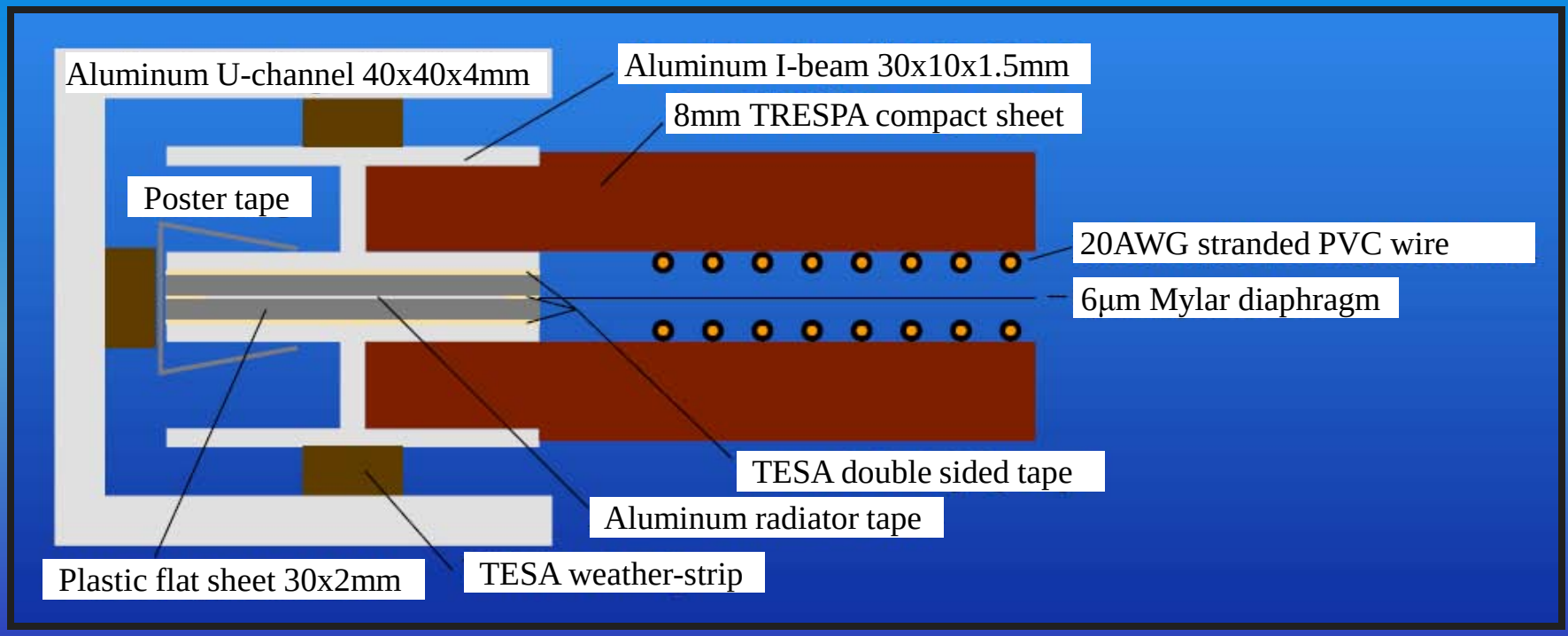
Effective step-up ratio



Impedance



ESL-33 stator construction



ESL-33 construction photos

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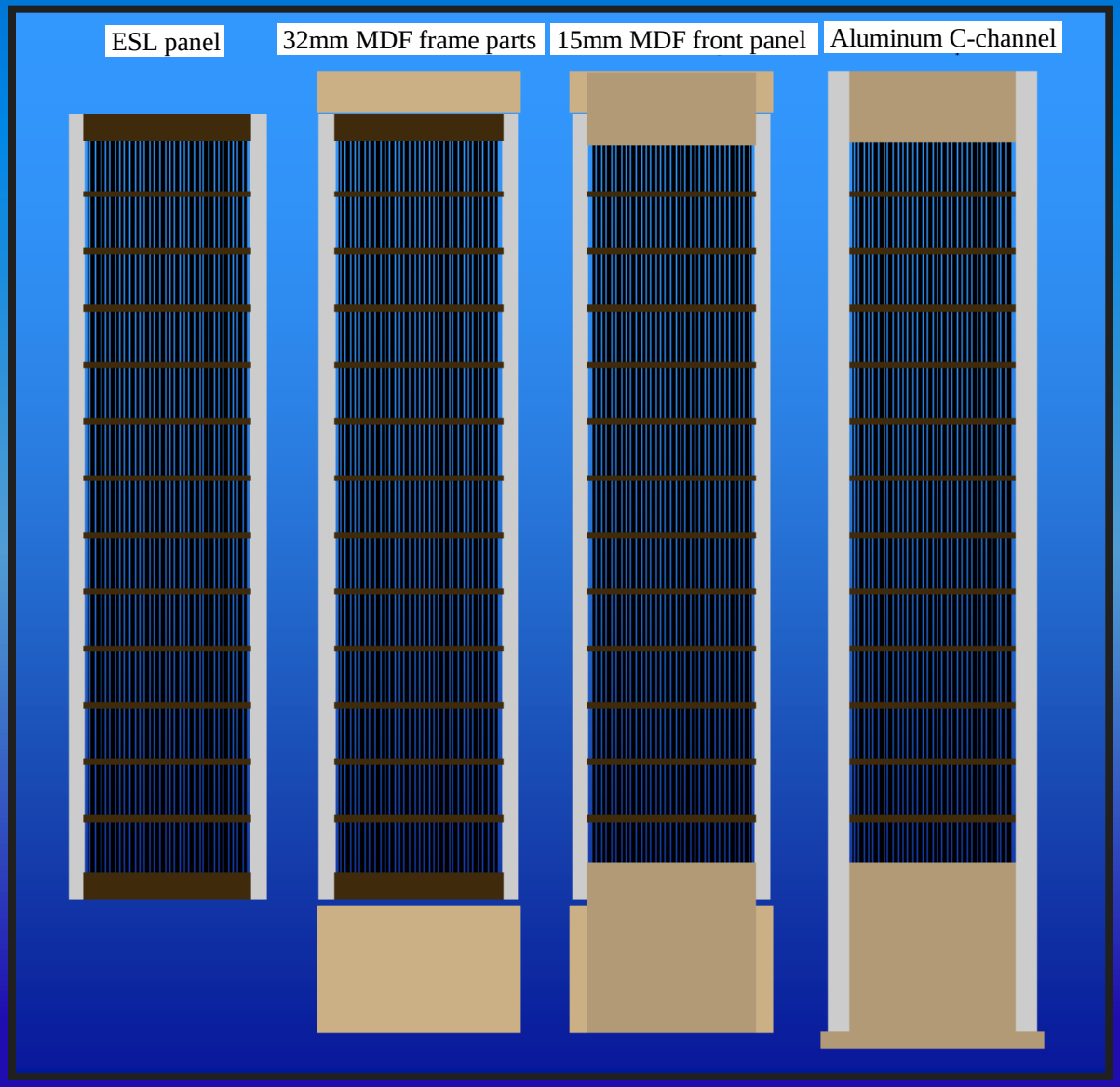
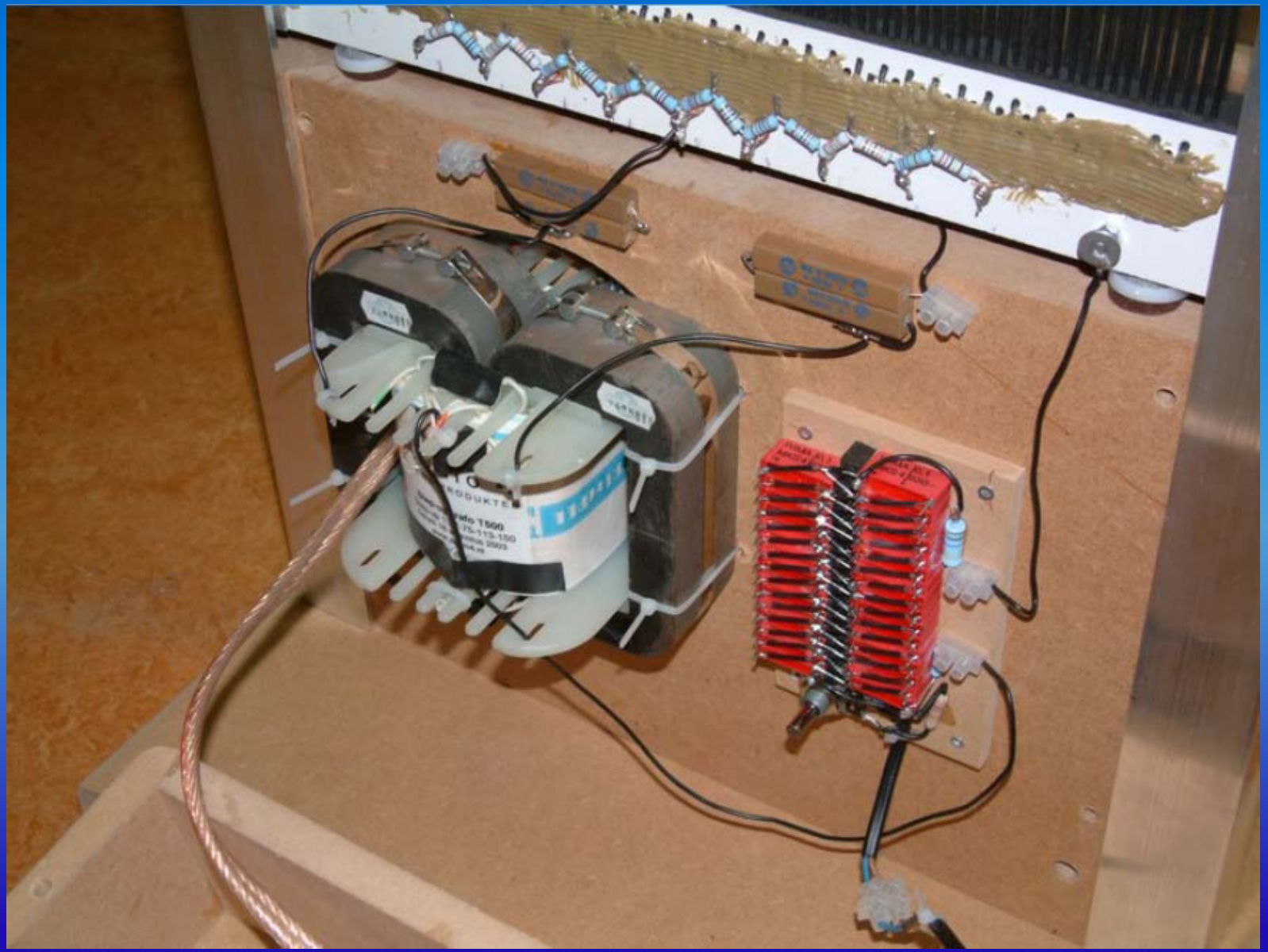
ESL-33 Assembly Layers





DIY tips

- Take a bag along with patience and time!
- Beware of high voltage!
- Check esl.hifi.nl and visitor an ESL meeting!
- Check out the DIY projects www.audiocircuit.com
- Join the forum ESL ESL Yahoo and read the forum posts from the past.

Acknowledgements

Martin-Jan Dijkstra (tips, materials)

- Jose Nebrus (tips, ideas)
- Peter Scheulderman (stator construction)
- Rob de Lugt (step-up transformer)
- Delft University, Department of Acoustics (theory)
- …