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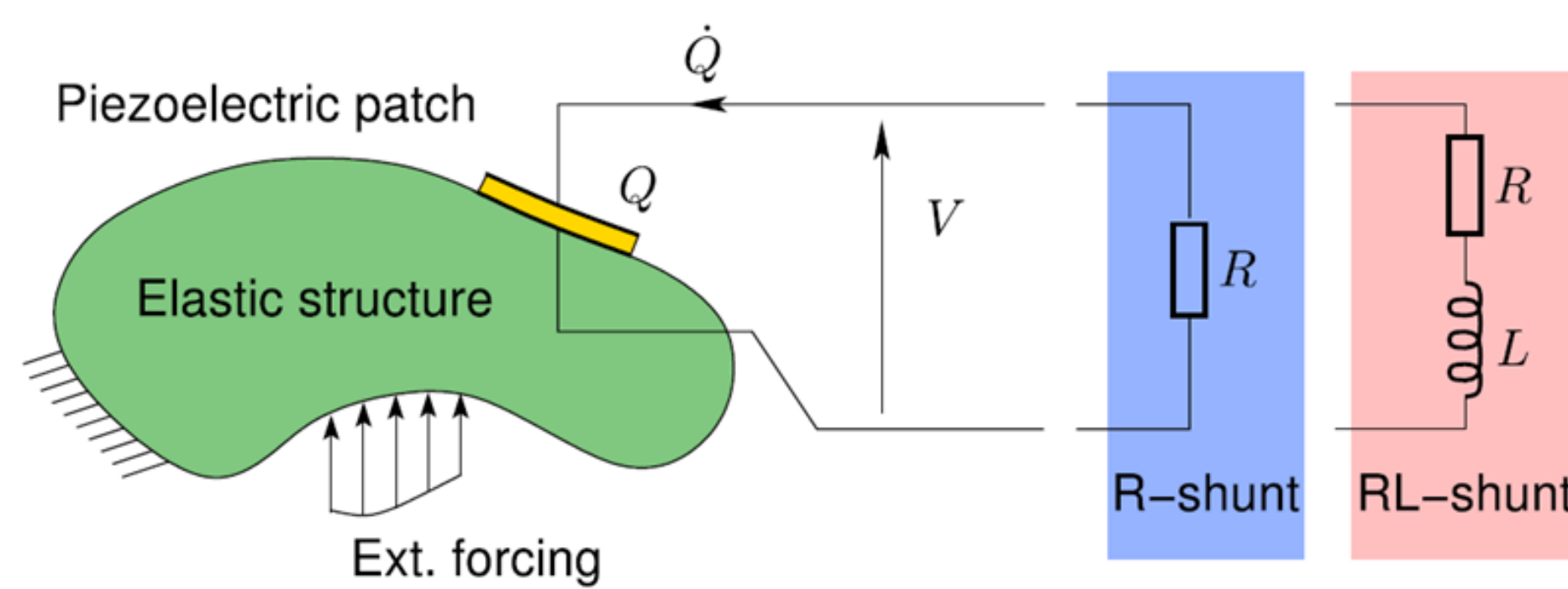
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Multimodal vibration damping through a periodic array of piezoelectric patches connected to a passive network

Context and motivations

• Vibration control with piezoelectric patches

- ▷ Deformation of a patch = Displacement of electric charges
- ▷ Energy conversion followed by dissipation into resistors
- ▷ Potentially light and passive control solution
- ▷ Resonant shunt \approx Tuned mass damper



• Limits observed with the resonant shunts

- ▷ High inductance required = No practical passive solution
- ▷ Sensitive and difficult tuning of multiresonant shunts

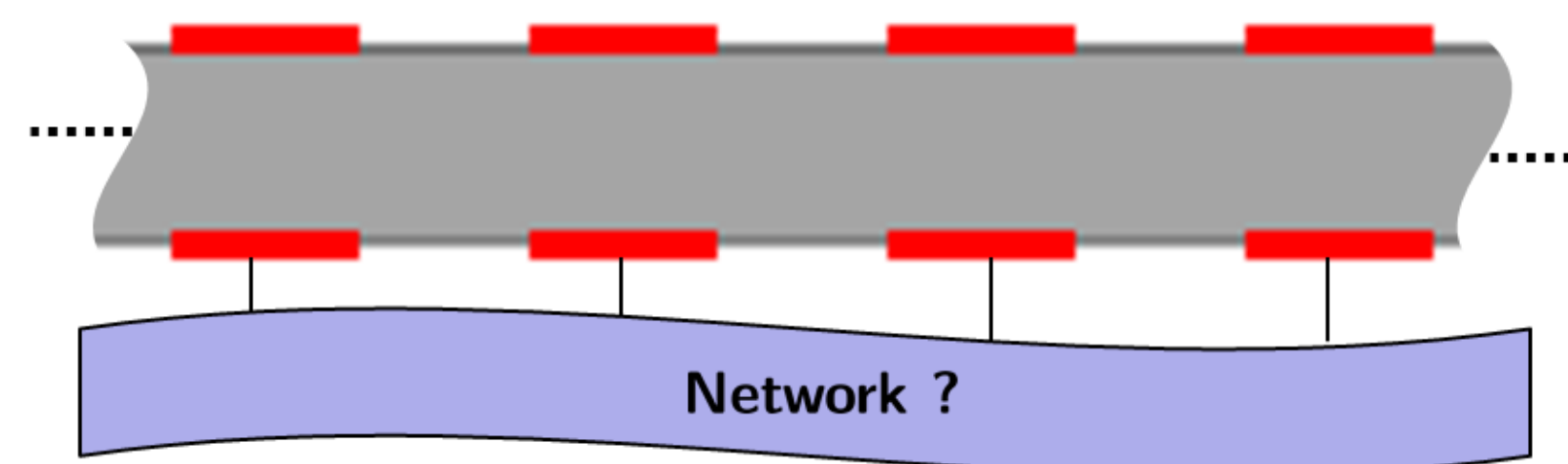
• Goal of the present study

- ▷ Propose a passive and broadband control strategy

Multimodal coupling

• Modal coupling principle

- ▷ Two structures having the same modal properties
- ▷ Similar boundary conditions and dispersion relations
- ▷ Multimodal tuned mass damping effect



• Application to the piezoelectric control

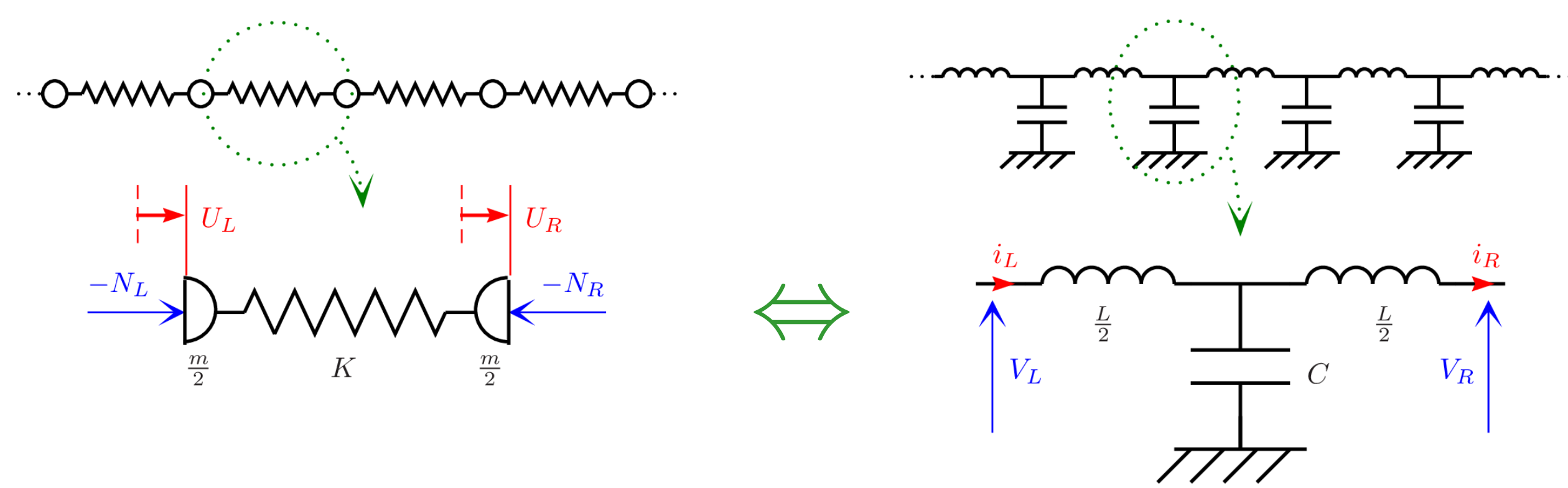
- ▷ Involve a multimodal electrical network

• Questions

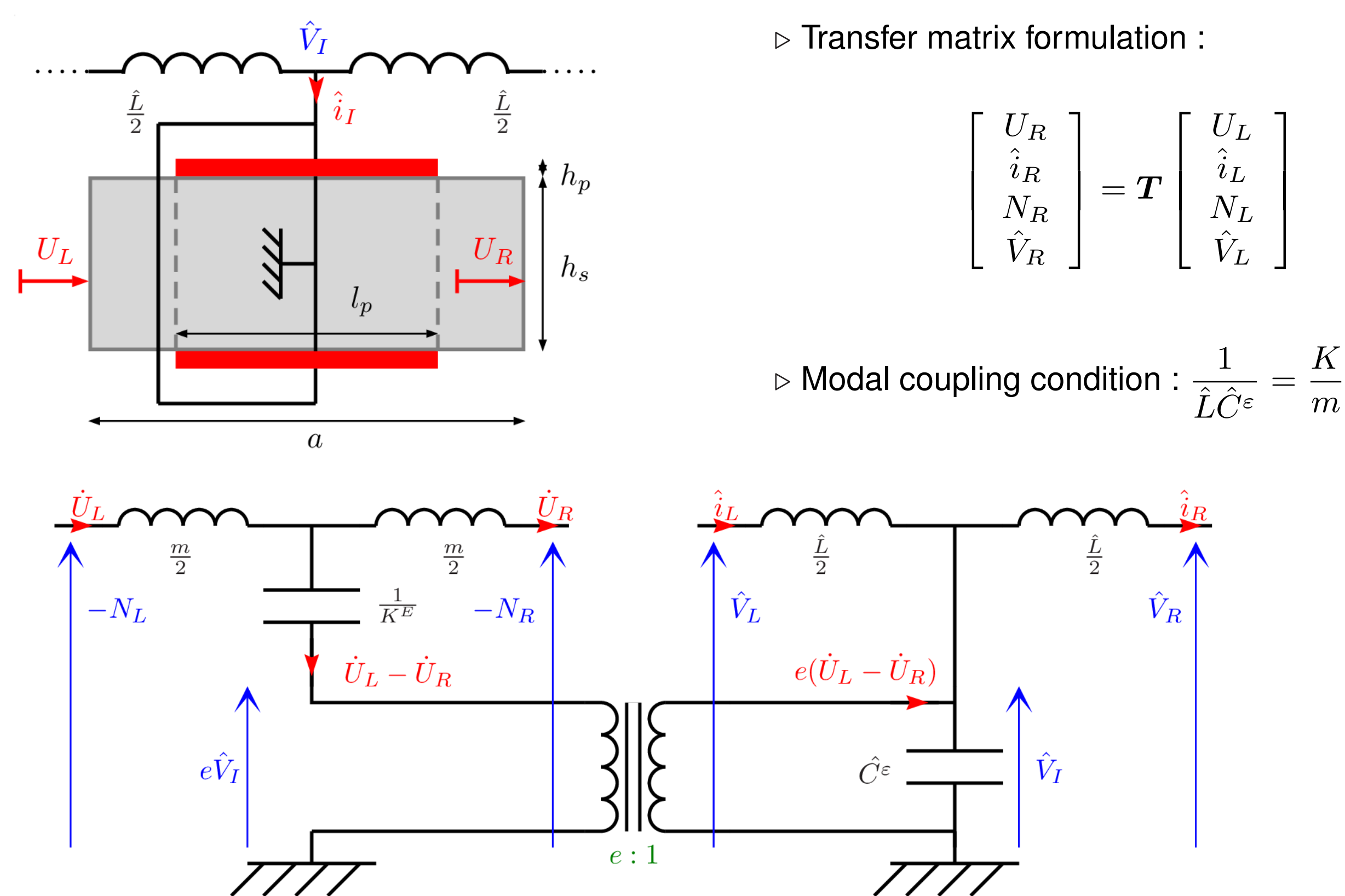
- ▷ Which electrical network ?
- ▷ How to apply and model an electromechanical coupling ?

Control of longitudinal waves

• Discrete model of a rod and its electrical analogue

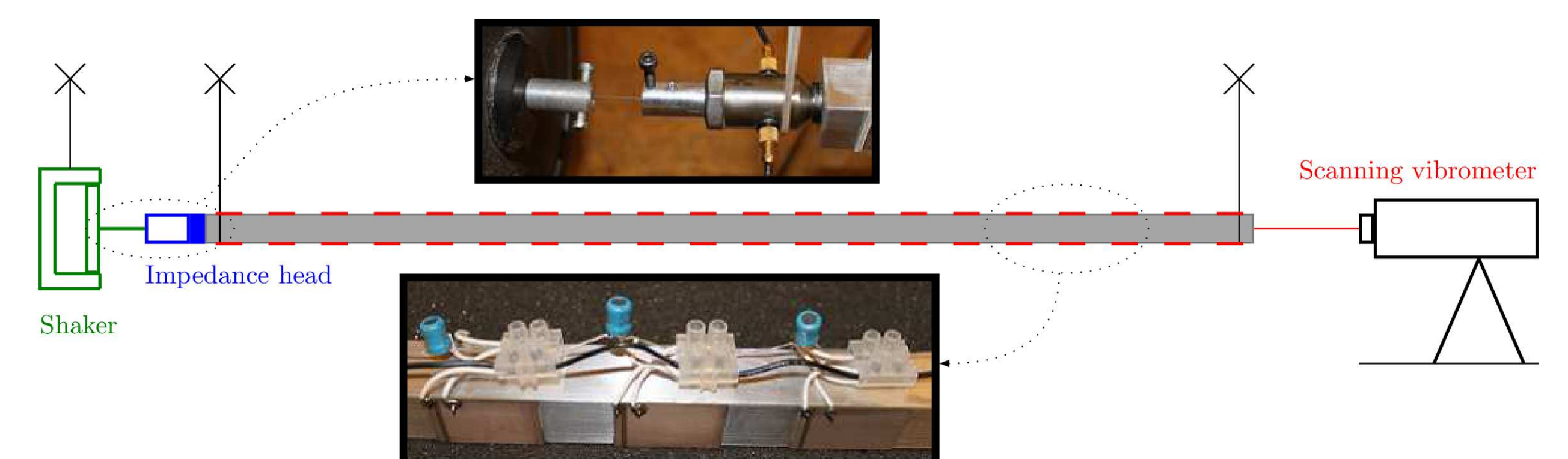


• Unit cell of the coupled problem and its discrete electrical representation

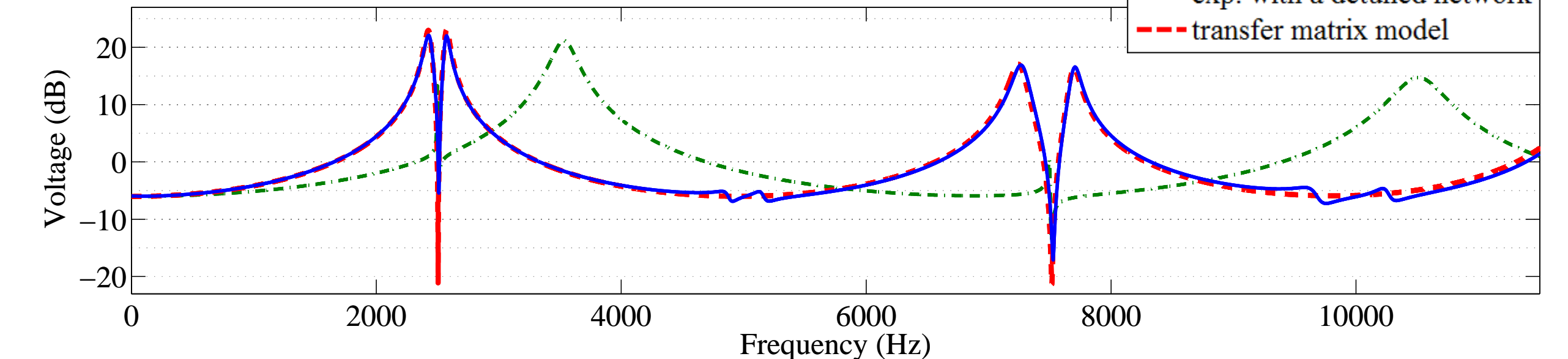


• Experiments on a rod covered with 20 pairs of piezoelectric patches

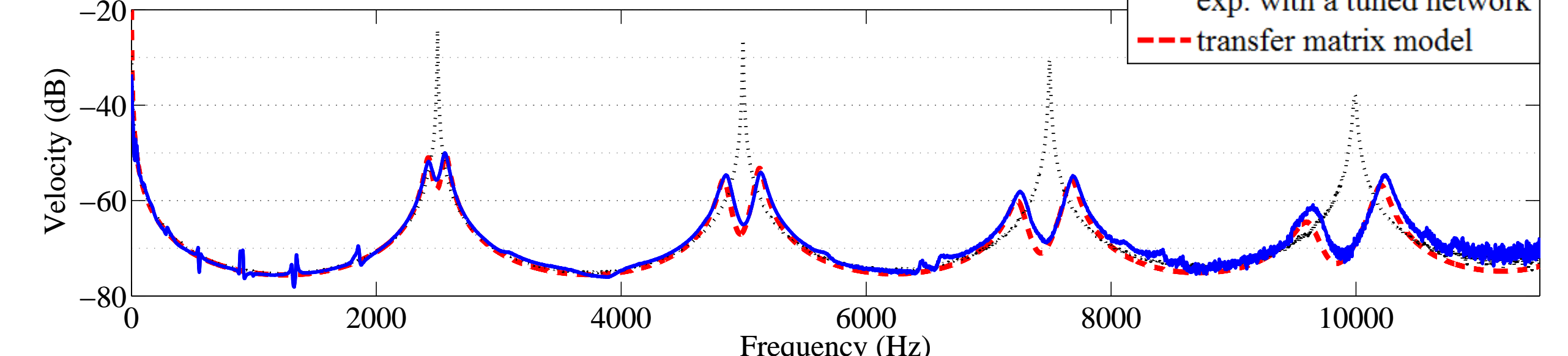
▷ Experimental setup:



▷ Voltage measurement in the middle of the network:



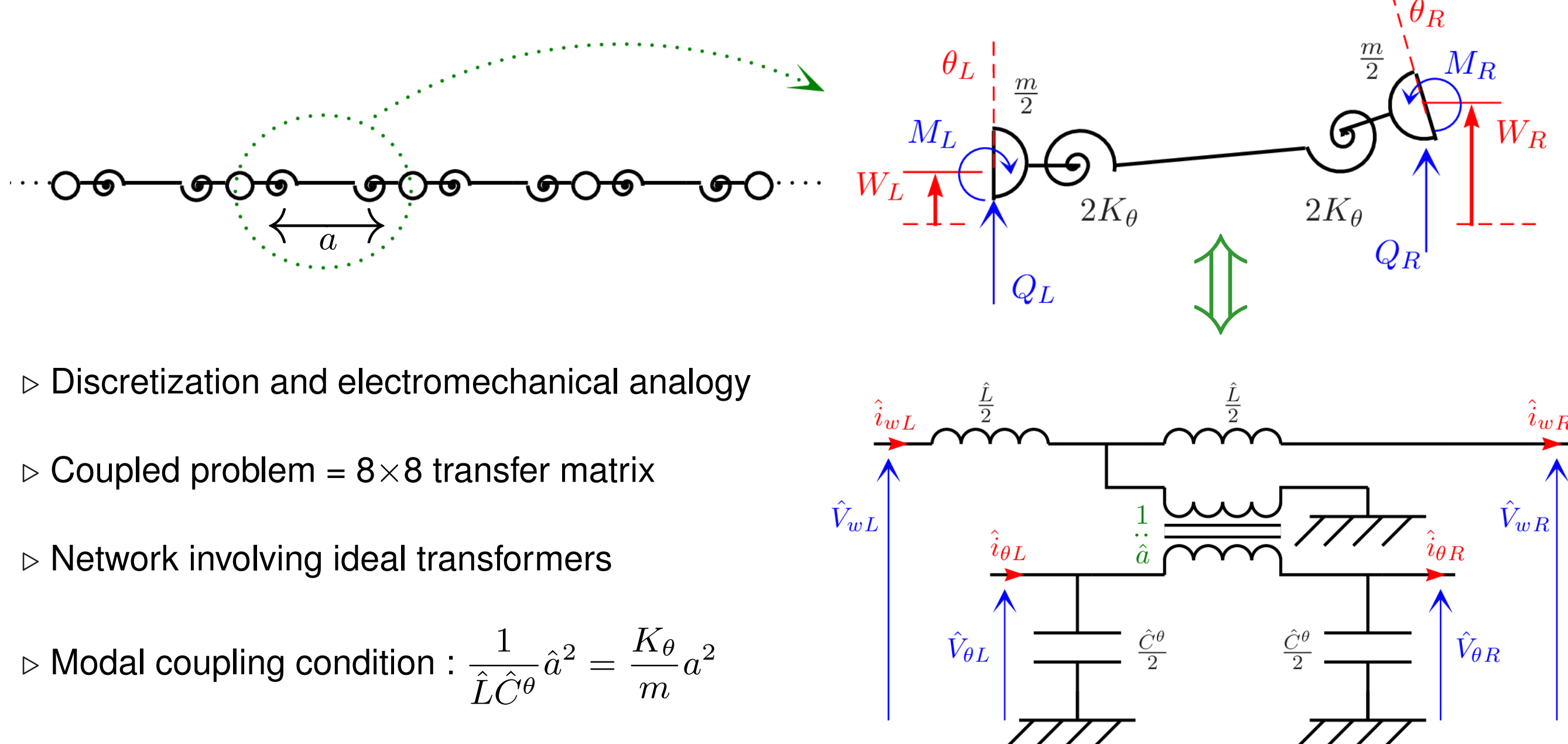
▷ Velocity measurement at the free end of the rod:



▷ Conclusion = Validation of the multimodal damping strategy and the transfer matrix model

Control of transverse waves

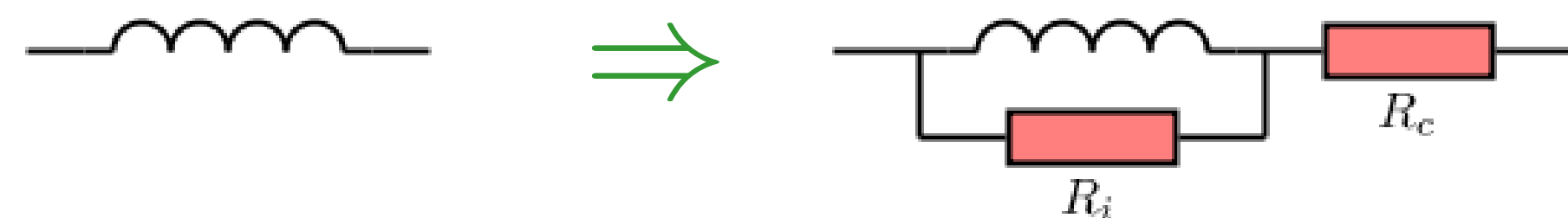
• Discrete model of a beam and its electrical analogue



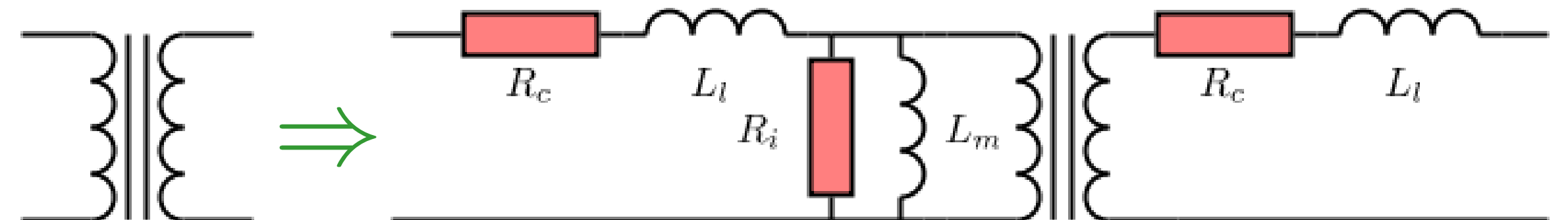
- ▷ Discretization and electromechanical analogy
- ▷ Coupled problem = 8×8 transfer matrix
- ▷ Network involving ideal transformers
- ▷ Modal coupling condition : $\frac{1}{LC^\theta} \hat{a}^2 = \frac{K_\theta}{m} a^2$

• Models for standard passive components (under consideration)

▷ Inductor:



▷ Transformer:



- ▷ Parasitic effects: copper and iron losses (R_c & R_i), leakage and magnetizing inductances (L_i & L_m)
- ▷ Difficulties when selecting standard electrical components

Future work

Short-term

Experimental validation of the multimodal damping for bending

Medium-term

Extension of the strategy to the control of plates with a 2D network

Long-term

General formulation for the control of any mechanical structure

References

- [1] O. Thomas, J. Ducarne, J.-F. Deü, *Performance of piezoelectric shunts for vibration reduction*, Smart Materials and Structures, Vol. 21, No. 1, IOPscience (2012), p. 015008.
- [2] C. Maurini, F. dell'Isola, D. Del Vescovo, *Comparison of piezoelectronic networks acting as distributed vibration absorbers*, Mechanical Systems and Signal Processing, Vol. 18, No. 5, Elsevier (2004), pp. 1243-1271.
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