MECA-H-524
- Project Description -

Introduction

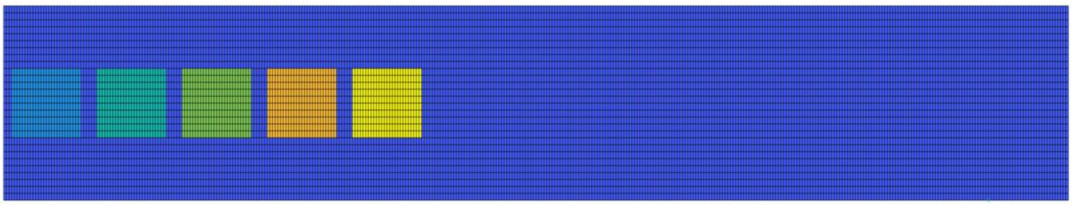
You are working as a NVH engineer within a company that develops solar panel for space applications. You are currently working on a project for which you have to deliver solar panels with custom-made fixations. Unfortunately, you just received the results from a vibration test you ordered and it appears that the different panels are too sensitive to vibrations. You therefore need to implement a control strategy to **increase the damping** of the system **for the first five resonances**.

To do so, you can use up to five piezoelectric patches without being above budget. You therefore implemented those five patches on your finite element software and you extracted the state space system. Your mission is now to play with your state space model in order to find out how many patches you should use, where the best locations are and what control law you should implement.

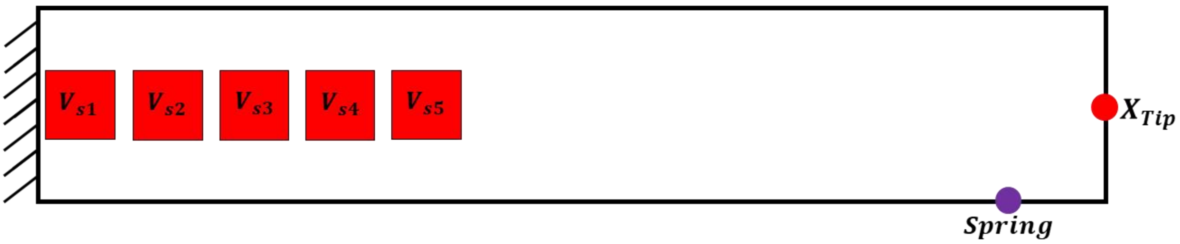
Technical aspect

The solar panel model

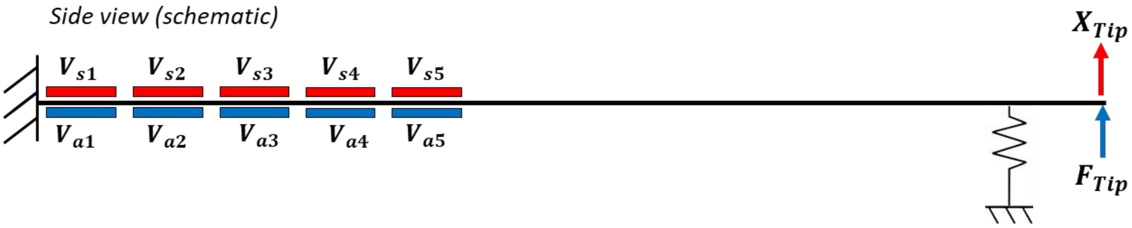
Top view (FEM software)



Top view (schematic)



Side view (schematic)



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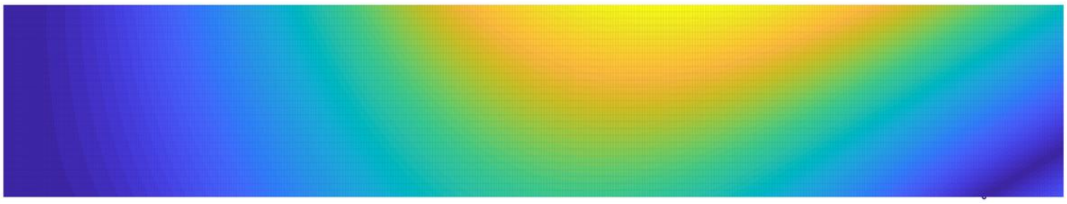
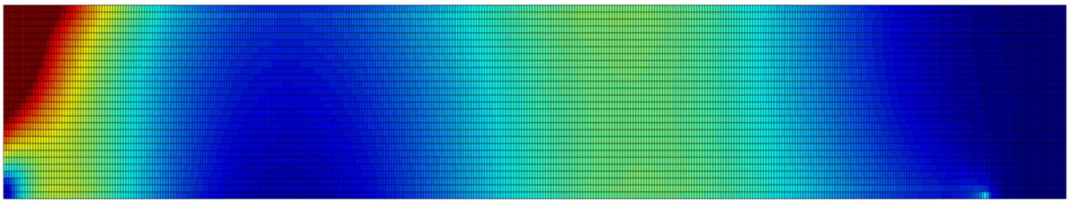
The modal analysis

Mode 1 – Magnitude of displacement

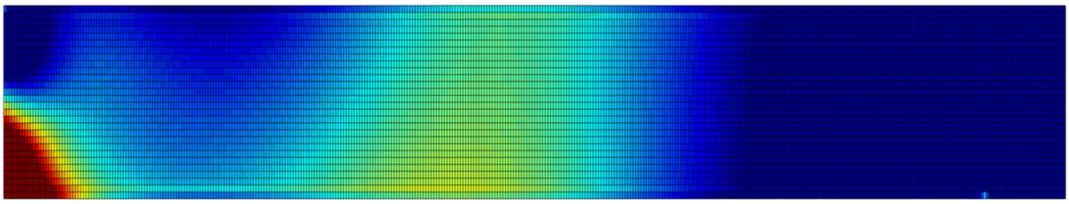


Mode 1 – Strain Map

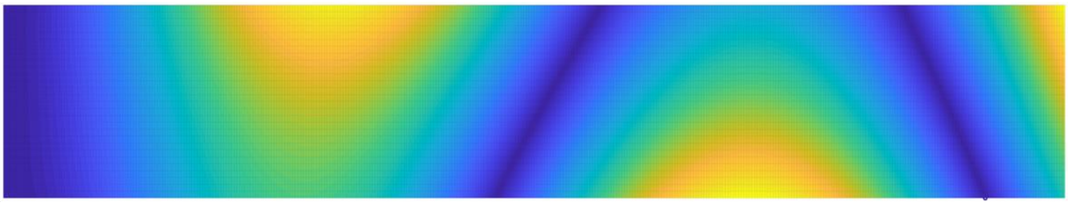


Mode 2 – Magnitude of displacement

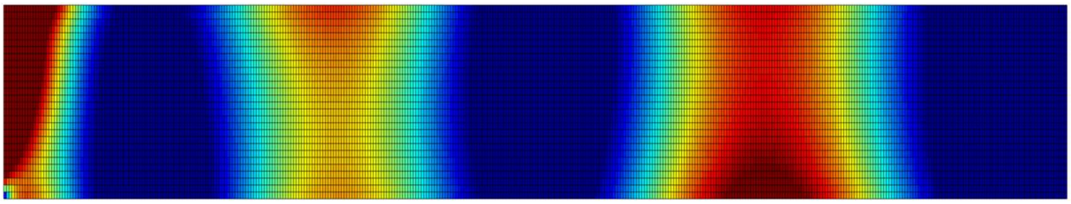
Mode 2 – Strain Map



Mode 3 – Magnitude of displacement



Mode 3 – Strain Map



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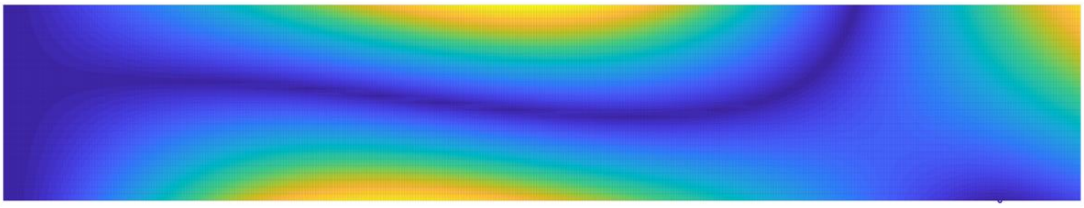
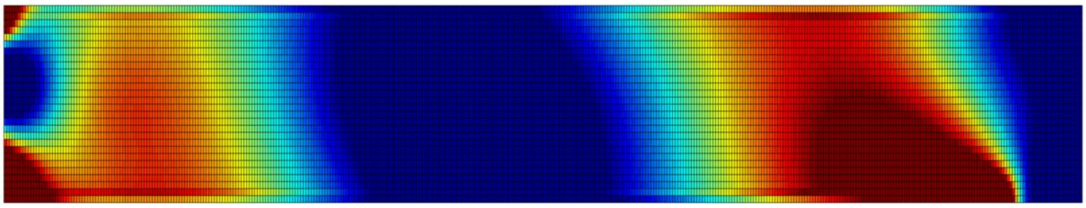
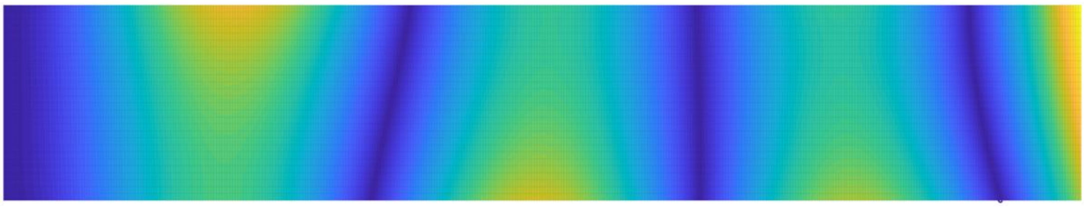
Mode 4 – Magnitude of displacement



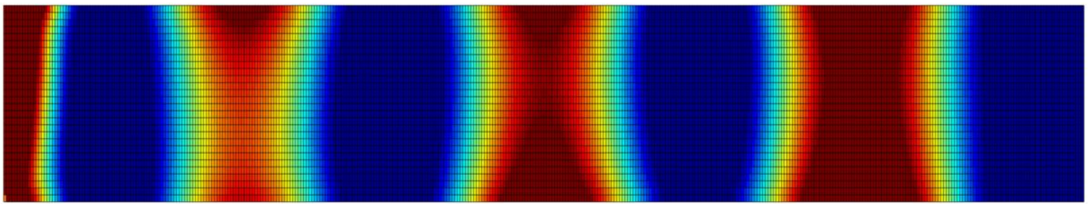
Mode 4 – Strain Map



Mode 5 – Magnitude of displacement



Mode 5 – Strain Map



The state space system

The structure is excited by an external force at the free-end of the solar panel (F_{tip}). A displacement sensor is placed at the same location (X_{tip}) to illustrate the vibration and to build the performance index.

In order to damp the resonances of the system, five pairs of piezoelectric patches are mounted on the structure. Each pair is composed of two patches: one actuator (on the bottom of the panel) and one sensor (on the top). Both are voltage-based, meaning that the voltage is injected to the piezoelectric actuators through V_{ai} while V_{si} is used to measure the voltage at the collocated sensor.

The state space model is available in the UV, as a .mat file.

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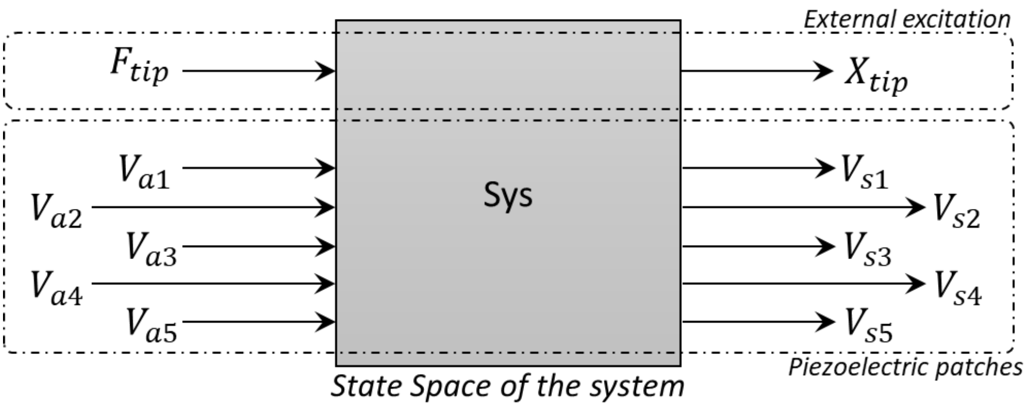

Guidelines for the project

The objective of the project is to damp the first five resonances of the system. Here are some guidelines to structure your work:

- Plant model
  - Familiarize yourself with the model provided in terms of inputs and outputs.
  - Plot the compliance (performance index).
  - Plot the open-loop transfer functions from different actuators to different sensors.
  - What are the differences between the open-loop transfer functions in terms of pole/zero patterns?
  - Which pair(s) of piezoelectric patches would you choose? And why?

- SISO controller
  - By looking at the system responses, which control law(s) could you use?
  - Design and implement at least two different controllers on one pair.
  - Compare the results obtained with the two controllers in terms of control performance and performance index. Which control law did work better? Did you find any trade-off?
  - Repeat the previous tasks on the other pairs.

- MIMO controller
  - Design a decentralized controller with multiple transducers using at least two different control laws.
  - Compare the performance of multiple transducers vs. single transducer.

- What are the practical challenges to implement those control systems in reality?

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Examination

The project will be performed by **group of two students**. The examination will be based on your report and on your oral presentation:

The report

- The number of pages is limited to **20**.
- You can choose its structure. We however encourage you to start with a brief introduction and follow by addressing the different tasks.
- One report per group will be loaded in the UV. A dedicate section will be created in due time.
- The due date for the report submission will be communicated in due time after discussion with the student representative.

The oral defence

- The aim of the oral defence is to briefly present what you did for the project.
- It consists of **max 15 min presentation** and 15 min of questions.
- The date of the defence will be communicated in due time after discussion with the student representative.

Useful Matlab functions

- `s = tf('s');`
- `closed_loop = feedback(sys,controller,in_ID,out_ID);`
- `figure; rlocus(sys(out_ID,in_ID));`
- `figure; bodeplot(sys(out_ID,in_ID)); grid on;`
- `stability = isstable(sys);`
- `sisotool(sys(out_ID,in_ID),controller)`

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