University of Liège

Motivation & Control Problem

Linear control systems

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1 Choice of the topic

The chosen topic is : **Active mass damper**.

2 Context

The current engineering prowesses allow us to construct buildings higher and higher. These constructions are subject to various disturbances (mainly wind, but also earthquakes) that make them oscillate. They turn into giant pendulum and swing from left to right, sometimes moving several meters at the top ![1]

To reduce these oscillations, we use a passive system, called *tuned mass damper*, which consists of concealing a tuned and harmonic oscillator at the top of the tower. It is coupled to its movement and oscillates in phase opposition to recover the kinetic energy of the tower and thus reduces the oscillations.[2]

An active version of this system exists : the *active mass damper*. It consists of the same principle as the tuned mass damper but it is equipped with sensors and actuators to measure the oscillations of its environment and, via an algorithm, generate a movement for the mass that reduce, or totally remove, these oscillations.[3]

Our study field focuses on the active mass damper systems used to reduce the oscillations caused by the **wind** on **tall** buildings. More specifically, we will focus on a simplified model : a block linked to a spring (to simulate the oscillations of the building) and a smaller moving mass placed over it that stabilises the system.

This model is presented in figure 1.

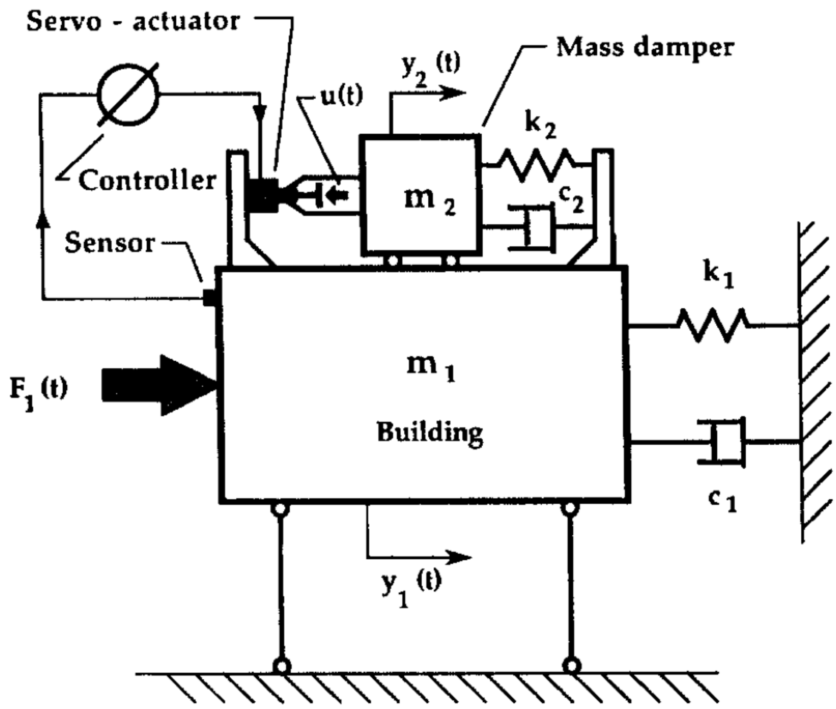

Figure 1 – Model of an active mass damper for the stabilization of a tall building [4]

3 Control problem diagram

The diagram of our control problem is shown in figure 2.

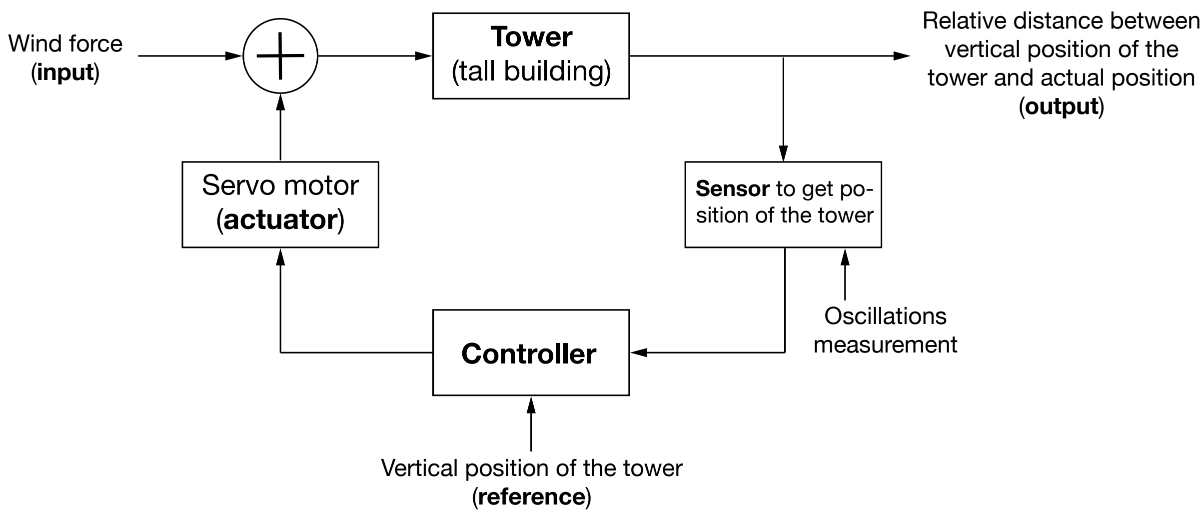

Figure 2 – Control problem diagram of the active mass damper for tall buildings

4 Control problem description

- **Utility of the controller** : the controller (the algorithm) allows the system (the tower) to be active, *i.e.* to measure the oscillations to which it is subjected and to cancel it. Thanks to a servo-motor connected to the controller, the mass can move and reduce, or even eliminate totally, the oscillations.
- **System to be controlled** : the tower (and the position of the tower is the signal)
- **Inputs of the system** : wind forces acting on the tower (uncontrollable) and on the moving mass (controllable).
- **Outputs of the system** : the relative distance between the vertical position and the displacement of the tower.
- **Reference** : the vertical position of the tower.
- **Actuators** : servo-motor to move the mass that reduces the oscillations.
- **Constraints and limitations** : to simplify our system, we consider a tower 500 m high, perfectly vertical when it undergoes no disturbance. The only disturbance on this tower is the strength of the wind. The wind, ranging from a few tens of km/h to a hundred km/h, can swing the tower from a few centimetres to several meters.

5 References

[1] *How To Stop Structures from SHAKING: LEGO Saturn V Tuned Mass Damper.* https://www.youtube.com/watch?v=ft3vTaYbkdE. Accessed : 2019-09-29.

[2] *Tuned mass damper.* https://en.wikipedia.org/wiki/Tuned_mass_damper. Accessed : 2019-09-29.

[3] *Active vibration control of structure by Active Mass Damper and Multi-Modal Negative Acceleration Feedback control algorithm.* https://www.sciencedirect.com/science/article/pii/S0022460X16307957. Accessed : 2019-09-29.

[4] *Parametric study of active mass dampers for wind-excited tall buildings.* https://www.sciencedirect.com/science/article/pii/0141029695001088. Accessed : 2019-10-08.

[5] *Parameter identification for active mass damper controlled systems.* https://iopscience.iop.org/article/10.1088/1742-6596/744/1/012166/pdf. Accessed : 2019-09-29.

[6] *Active Mass Damper - One Floor (AMD-1).* https://www.made-for-science.com/de/quanser/?df=made-for-science-quanser-active-mass-damper-coursewarestud-matlab.pdf. Accessed : 2019-09-29.