Applied Vehicle Dynamics Control SD2231

Lab 3

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Introduction

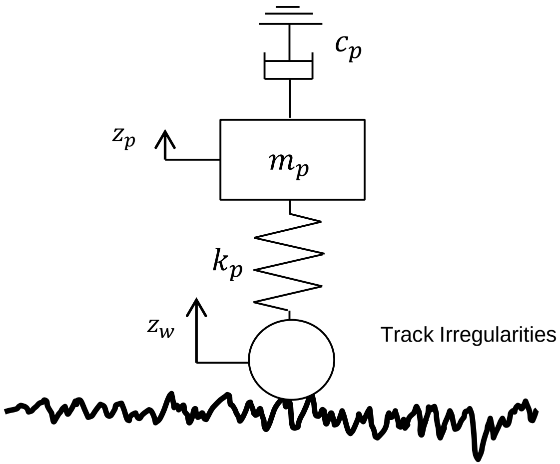
- laboratory aim: control vehicle vibration to improve passenger comfort

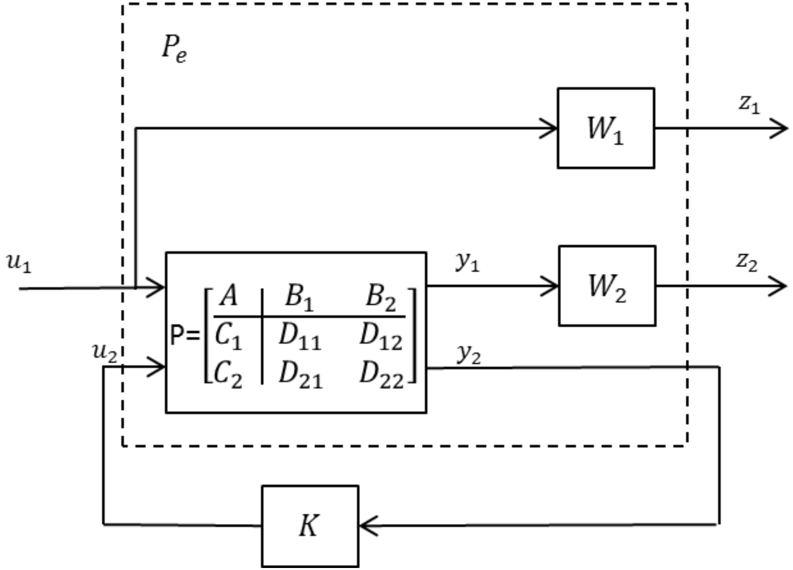
- To achieve acceptable vibration level, suspension system is used.
- Passive suspension: springs and dampers
- Active suspension

- Controllers you will use: PD, PID, skyhook and H_∞

Theory

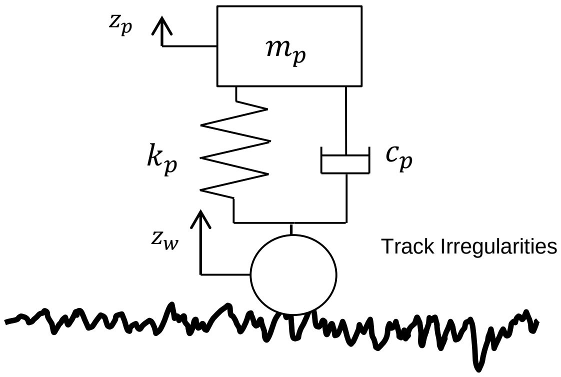
- Skyhook controller
- H_∞ controller





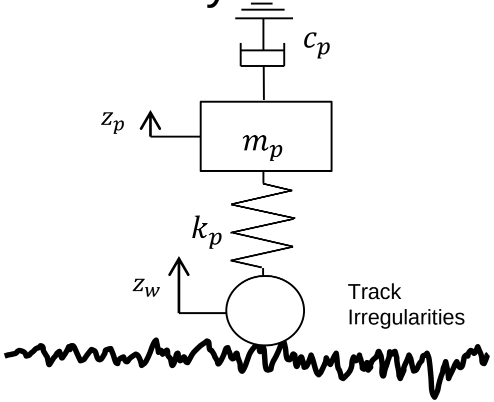
Skyhook

Damper



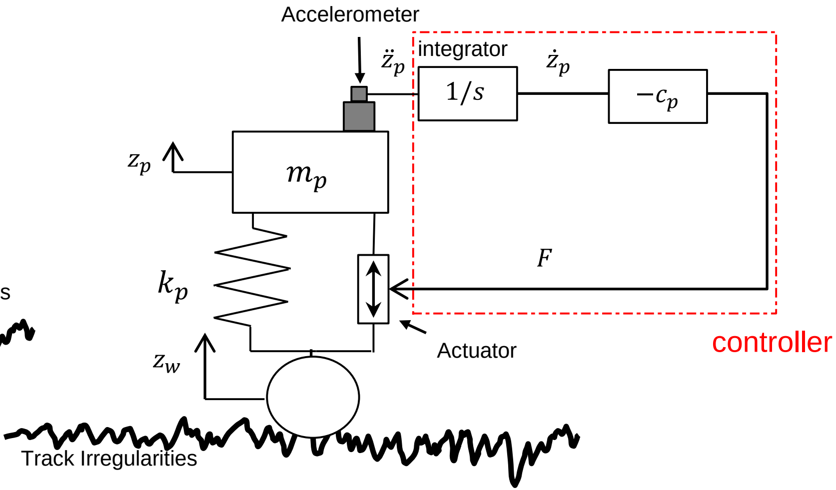
$$F_{c_p} = -c_p.(\dot{z}_p - \dot{z}_w)$$

Skyhook



$$F = -c_p.\dot{z}_p$$

Implementation:



- Vibration isolation by decoupling the body from track or road irregularities.

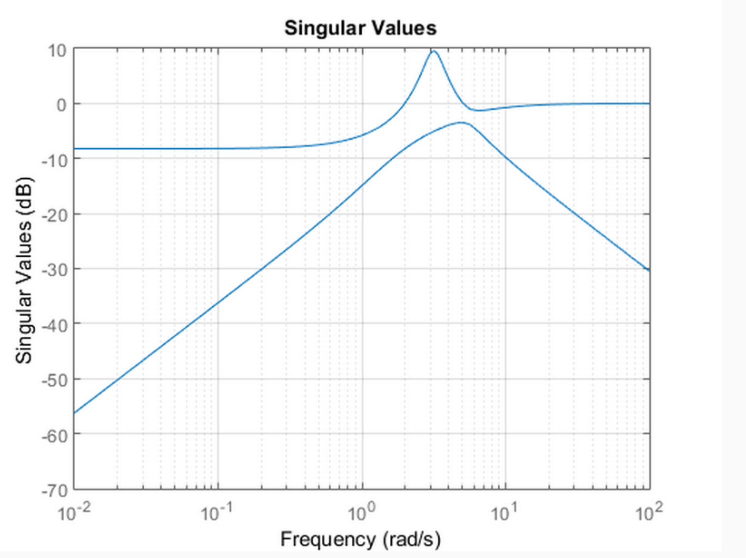
H_∞ norm:

Infinity norm of a SISO system with transfer function $P(s)$ is:

$$\|P(s)\|_\infty = \sup_w |P(iw)|$$

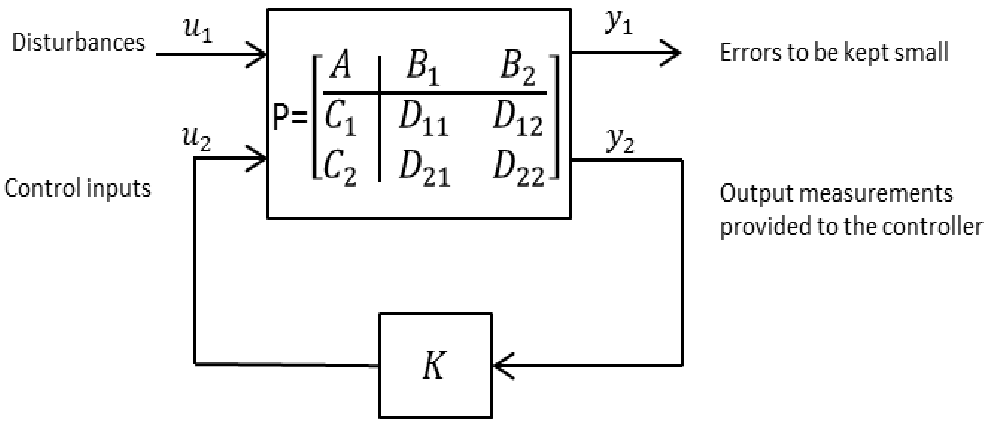
For a MIMO system:

$$\|P(s)\|_\infty = \sup_w |\bar{\sigma}(P(iw))|$$



H_∞ controller principle:

Consider plant P



The aim is to design a controller so that the infinity norm of the closed-loop system (CL) is minimum.

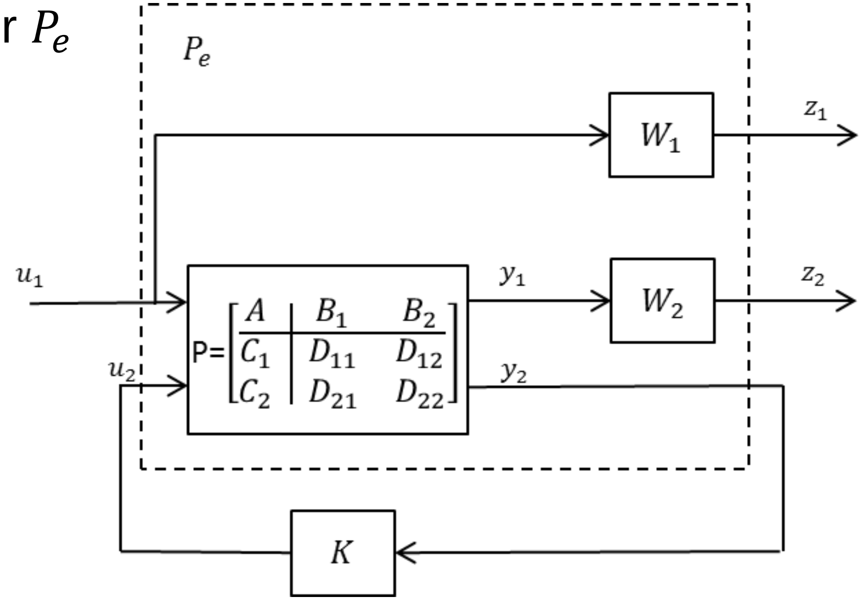
$$\gamma = \|CL\|_\infty$$

$$\min(\gamma)$$

Extending the model P with weighting functions

One can extend the model P with weighting functions.

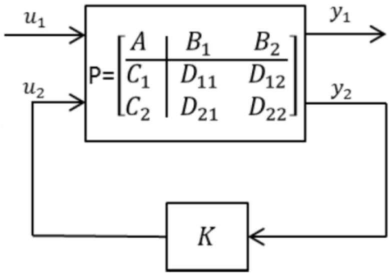
Design controller K for P_e



Why? to penalize the desired signals at the desired frequencies.

Contd.

Having the weighting functions, controller K can be designed by MATLAB.



Test: to check the performance of the derived controller K, it should be implemented in the control loop of the main model.

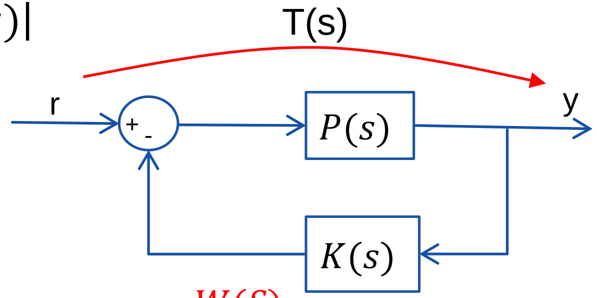
Unsatisfactory response: Change the weighing functions and look for a new controller.

H_∞ concept

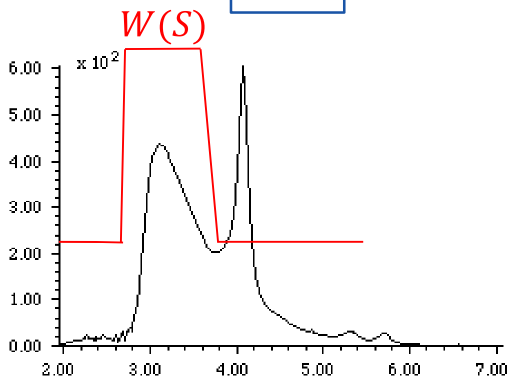
H_∞ norm:

of a transfer function is its maximum magnitude over the whole frequency range.

$$\|T(iw)\|_\infty = \sup_w |T(iw)|$$

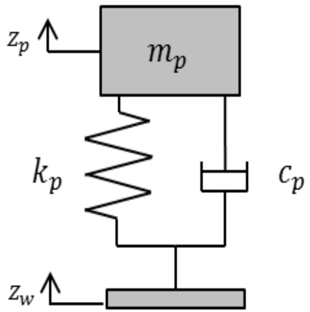


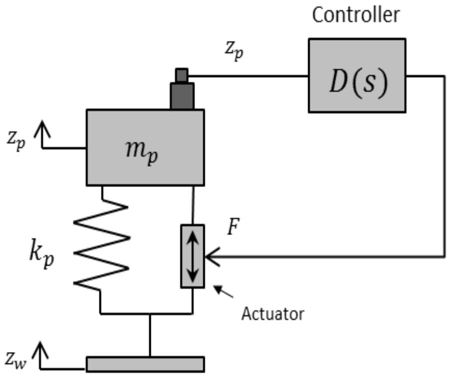
H_∞ control tries to design the controller K such that the infinity norm of the closed loop transfer function $T(s)$ is minimized.



We can focus this minimization process on specific frequency ranges by proper weighting functions $W(s)$ (penalizing)

Control of a single degree of freedom (SDOF) system



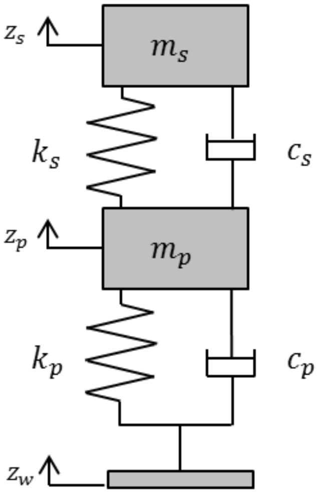


Passive
- Damped
- Undamped

Active
- PD
- PID
- Skyhook

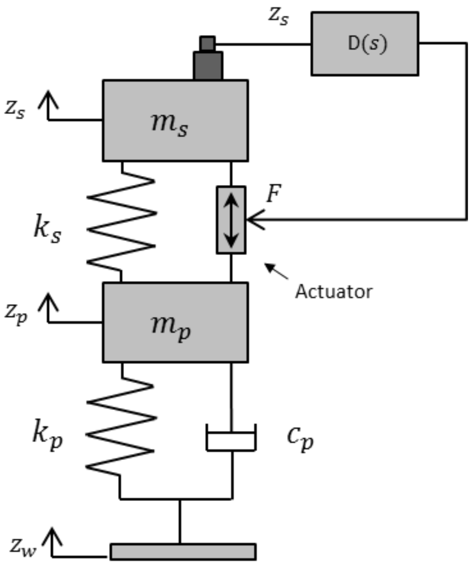
Excitation:
- Sinusoidal excitation
- Impulse response
- Response to track excitation (PSD)

Control of a 2 degrees of freedom system



Passive

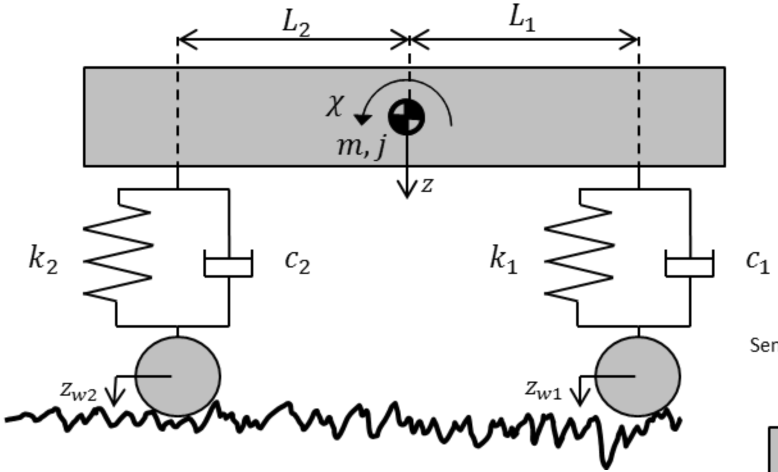
- Damped



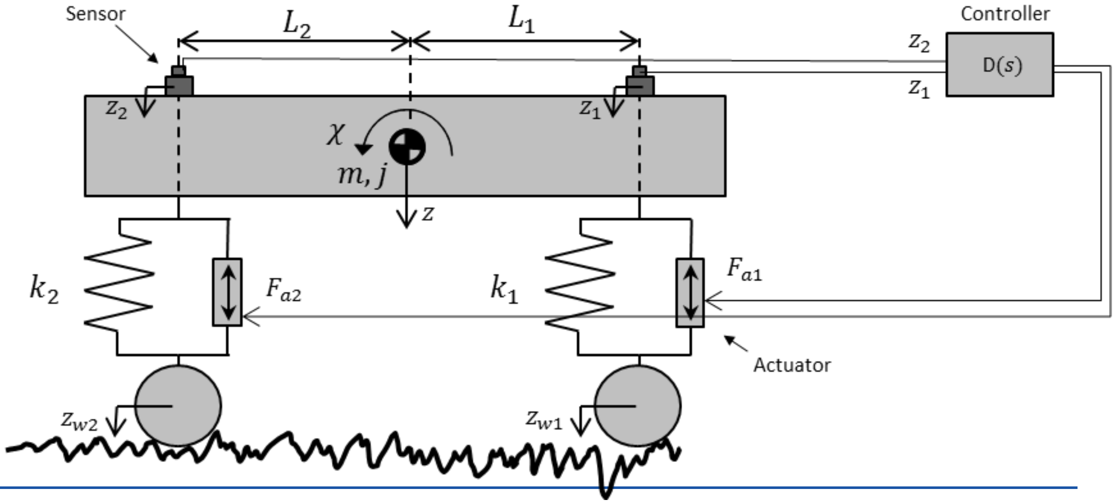
Active

- Skyhook

Control of bounce and pitch using Skyhook and H_∞



→ Passive system



Active system ←
- Skyhook
- H_∞

Report writing

- Read each chapter to the end before answering questions.
- Tasks marked as ‘midway step’ should be answered but you do not need to reflect them in the report.
- You should use the template on Canvas for your final report.
- Report grading: See grading criteria!

Other notes

Teachers supporting this Lab:

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Lab material:

- You find all necessary documents in Canvas under ‘files>Lab 3’
- Almost same presentation was recorded in 2020 and you can find it under ‘files>Lab 3>Presentation’

Supplementary material:

If you have problem with deriving Equations of motion and transfer functions, read chapter 5 of the ‘Rail Vehicle Dynamics’ book. This can be found on Canvas under ‘files>Lab 3>Supplementary material’ and the file is named ‘Rail vehicle dynamics-chap5’. Sections 5.1 and 5.3 can be very helpful.