Magnetic Levitation System (MagLev)

Description and modeling

A magnetic disk is constrained by an axle to move up and down. A repulsive magnetic force $L(t)$ acts on it. Such a force is generated by the current $i(t)$ flowing on a coil under the disk. Let $y(t)$ be the distance between the disk and the coil and let us assume to command the current $i(t)$. The force can be expressed as (the time index is omitted when clear from the context):

$$L(i, y) = \frac{i}{a(y+b)^4}$$

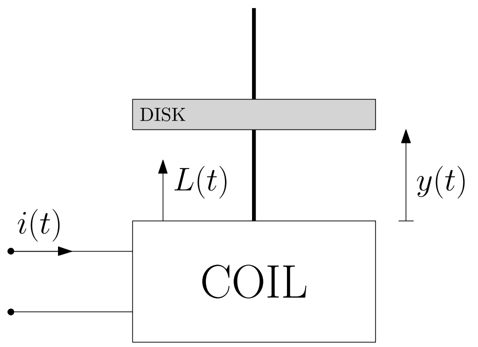
where a, b are given parameters.

The model of the system can be written as

$$m\ddot{y} = -mg - c\dot{y} + L(i, y)$$

where m is the disk mass and c is a parameter representing viscous friction.

Nominal numerical values: $a = 0.95,\ b = 6.28,\ c = 0.15,\ m = 0.12,\ g = 9.81$



Experience Goal

- Control the disk position in order to track a given reference signal.

Assignments

1. Build a Simulink model implementing the MagLev.

   Hint: provide an output related to the system states (it will be useful later).

2. Design a controller based on I/O Feedback linearization.

   Assume a reference $y_d(t) = A + B\sin(\omega t)$, with $A = 0.1,\ B = 0.05,\ \omega = 1$.

3. Find the interval of the controller parameters which guarantee asymptotic stability of the controlled system.

4. Change the controller parameters and comment the results.

5. Change the reference signal (try steps, square waves, etc.) and comment.

6. Insert an additive noise (e.g., a white noise) on the sensor and evaluate the performance of the previously designed controller. Try with disturbances of different amplitude.

7. Assume that the friction coefficient c is uncertain up to 20%. Set $\widehat{c} = 0.15$ and let the true parameter be equal to $c = \widehat{c} \pm 20\%$. Simulate the controlled system by choosing $c = 1.2\,\widehat{c}$.

8. Design a Sliding Mode controller considering the uncertainty on the parameter c.

9. Change the SMC parameters and comment the behavior.

10. Compare the performance of the two designed controllers (FL and SMC) and discuss.

11. Assume that also the parameter a is affected by uncertainty. In particular, assume $a \in [0.85,\ 1.05]$. Simulate the controlled system by setting $a = 0.85$ and $a = 1.05$, both for the FL and the SM controllers designed before. Comment the results.

12. Change the SMC parameters taking into account the uncertainty on parameter a, and comment the results.