

SOEN 385 - Final Project

Elevator Control System

Project Description

Design of an elevator for building or industrial use is under several constraints such as high safety and comfortable lift, of which we are interested in the latter in this project. An important factor in comfortable motion of the elevator is the start and brake accelerations which should be held in an acceptable range for human body.

An elevator control system has at least three use cases: elevator request, floor selection and stop request (if needed). For the elevator control program, these use cases can be modeled as numbers specifying floor requests that arrive at anytime. The system decides in which direction to move in order to best service **all** the requests, i.e. starvation should be avoided.

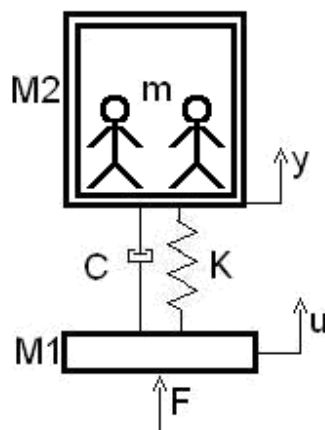


Fig. 1 Elevator model

Figure 1 shows a simple model of an elevator consisting of a chassis of mass $M1$ connected to a chamber (or room) of mass $M2$ by spring and damper. The total passenger mass is denoted by m .

When a floor is selected, the motor starts to insert a force to overcome the weights plus an additional force to accelerate the total system. The additional force increases gradually and then decreases until the total system (the elevator plus the passenger mass) reaches a definite velocity.

The transfer function between the motor additional force and the chamber velocity is as follows:

$$\frac{V}{F} = \frac{(Cs + K)}{s(M_1(M_2 + m)s^2 + (Cs + K)(M_1 + M_2 + m))}$$

Assuming an ideal motor response i.e. motor input-output transfer function being unity, the block diagram of closed loop system can be constructed as shown in Fig. 2.

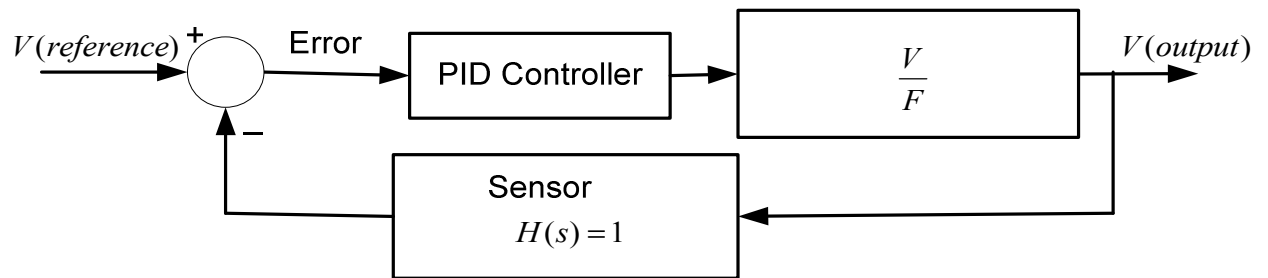


Fig. 2 Block diagram of closed loop system

In a typical application V is desired to change from 0 to 1 meters/second during at least 4 seconds with a maximum overshoot of 10%. Let:

$$M_1 = 150$$

$$M_2 = 200$$

$$m = 200$$

$$K = 20000$$

$$C = 1$$

Assignment

- 1) Using Matlab and Simulink or any other appropriate tool:
 - a- Design different PID controllers (P, PI, PD, PID) for the system and find out which controller can satisfy the above specifications.

In each case, analyze the stability of your system.

- b- Consider the case the total passenger mass is $2m$, without changing the controller designed in step a). How do the desired specifications change in this case?
 - c- Explain how you would design a controller that can satisfy the requirements for both cases of passenger mass to be m and $2m$?
- 2) Build an animation using Virtual Reality which simulates the whole system. Your software must have a user-friendly interface (GUI) to enable the user to change the parameters of the system and show the results. Usually in real applications the input is the floor number. In this case besides the velocity, the distance should be controlled. The area below the velocity–time curve is the actual distance traveled by the chamber and given by $d = \Delta x = \int V dt$ as shown in Fig. 3.

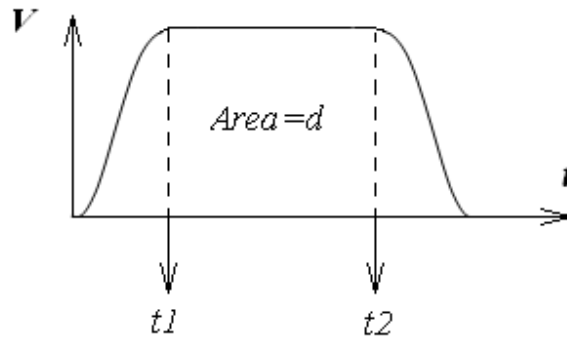


Fig. 3 Velocity changes in a typical upward course

A typical velocity command for this purpose can be approximated by Fig. 4.

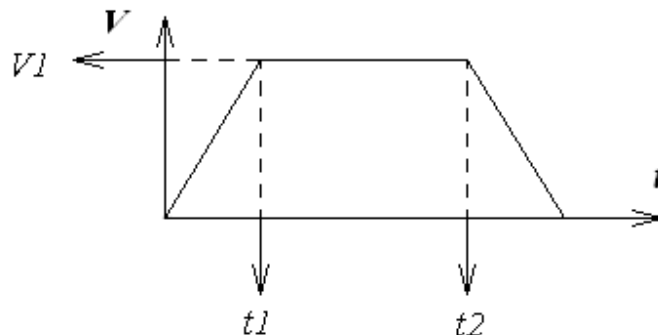


Fig. 4 Velocity command

Use your model designed before and try to find t_1 and t_2 such that the total distance would be about 3.5 meters (between two succeeding floors). Assume the

maximum speed V_1 is 0.5 meters/second which should be achieved during at least 1 second ($t_1 \geq 1$).

Further Reading

In this project we designed the controller for the case of only one elevator. The more general case of the problem is a multi-elevator system. The main challenge in the design of a multi-elevator system is the so-called problem of group scheduling which is a complex control task and has been extensively researched due to its practical importance. Furthermore, elevator dispatching (routing) itself can actually be seen as a version of the Traveling Salesman Problem (TSP), which is an NP-hard optimization problem.