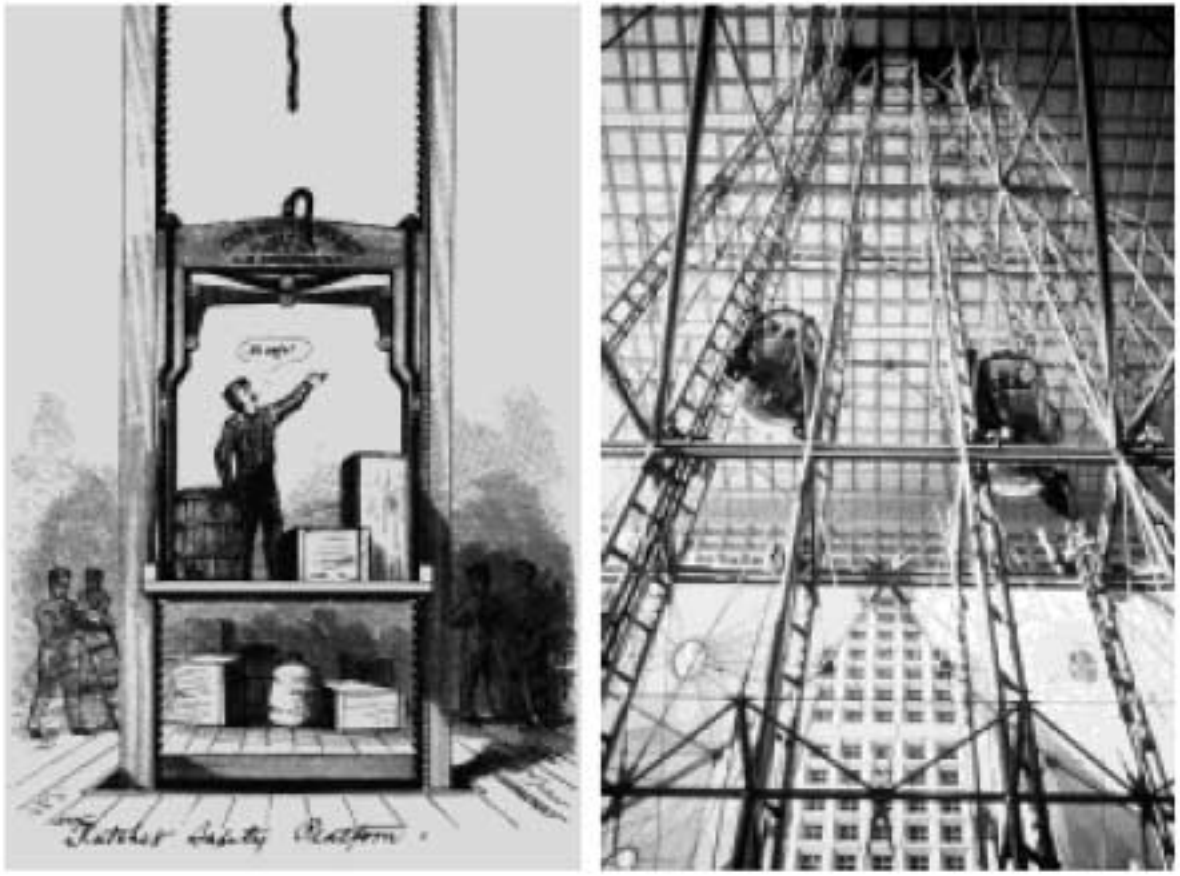
# Chapter 1

## Introduction

**Figure 1.1**
Simplified description
of a control system

**Figure 1.2**
**a.** Early elevators were controlled by hand ropes or an elevator operator. Here, a rope is cut to demonstrate the safety brake, an innovation in early elevators;
**b.** Modern Duo-lift elevators make their way up the Grande Arche in Paris, driven by one motor, with each car counterbalancing the other. Today, elevators are fully automatic, using control systems to regulate position and velocity.



(*a*) (*b*)

**Figure 1.3**
Rover was built to work in contaminated areas at Three Mile Island in Middleton, PA, where a nuclear accident occurred in 1979. The remote controlled robot's long arm can be seen at the front of the vehicle.

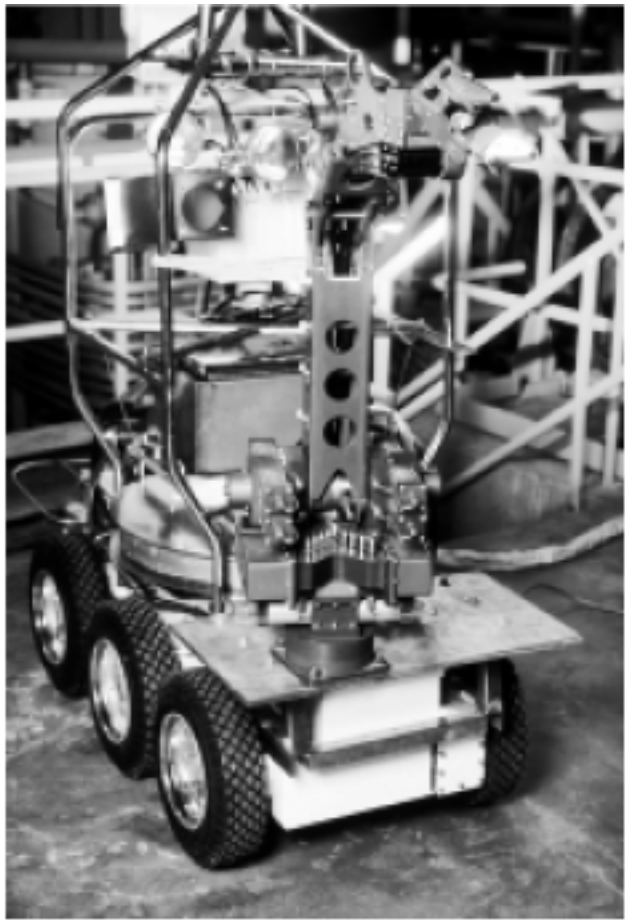
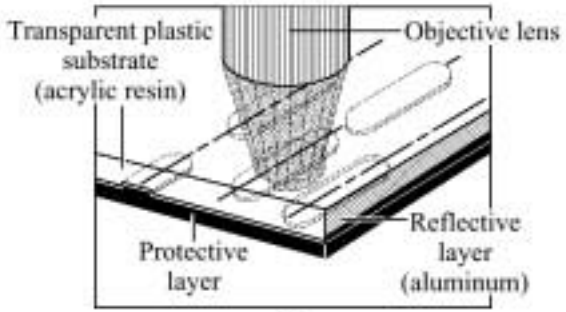
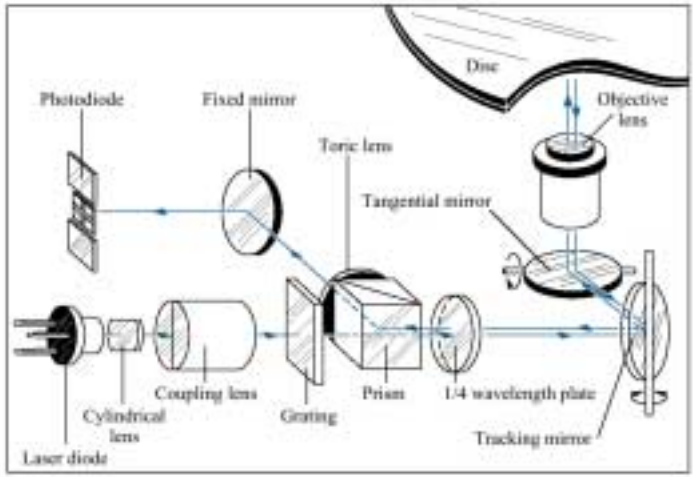


**Figure 1.4**
**a.** Video laser disc player;
**b.** objective lens reading pits on a laser disc;
**c.** optical path for playback showing tracking mirror rotated by a control system to keep the laser beam positioned on the pits.

(a)




(b)




(c)

**Figure 1.5**
Elevator input and output

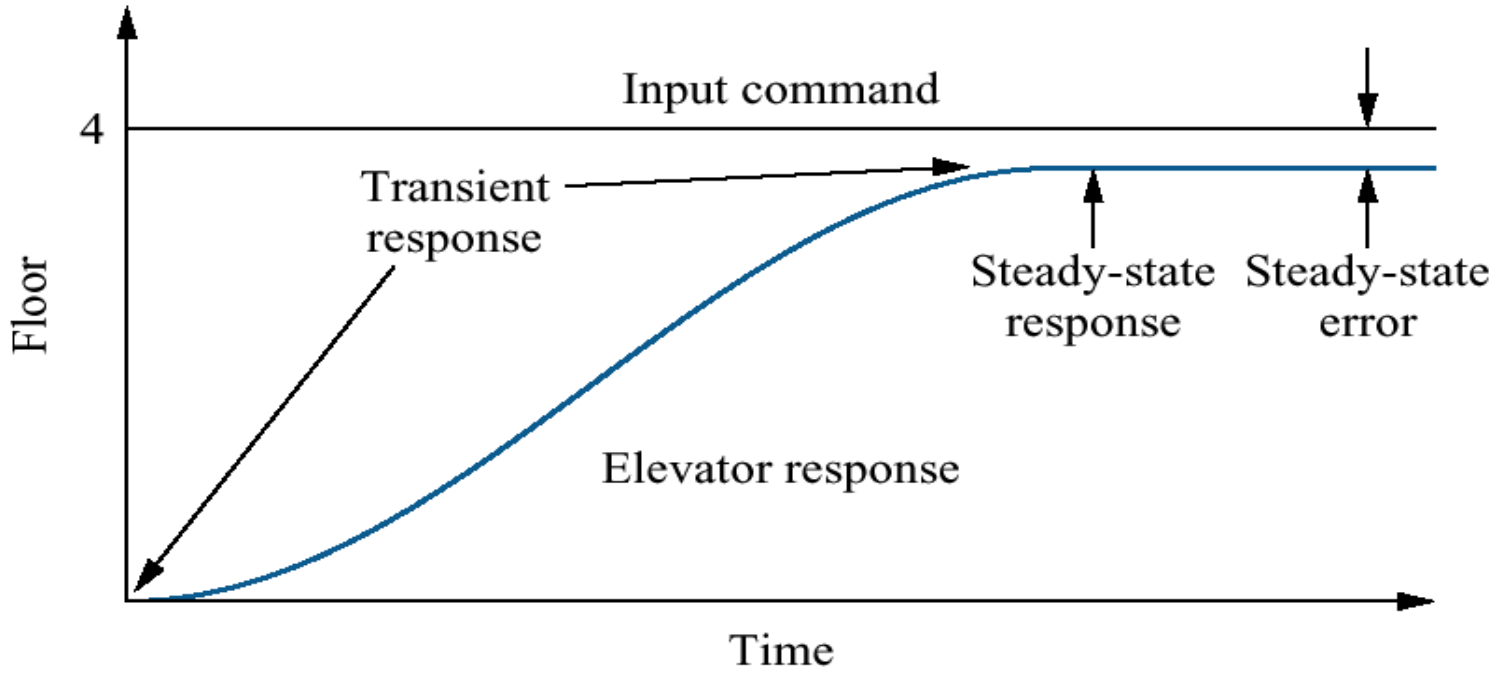


**Figure 1.6**
Block diagrams of control systems:
**a.** open-loop system;
**b.** closed-loop system

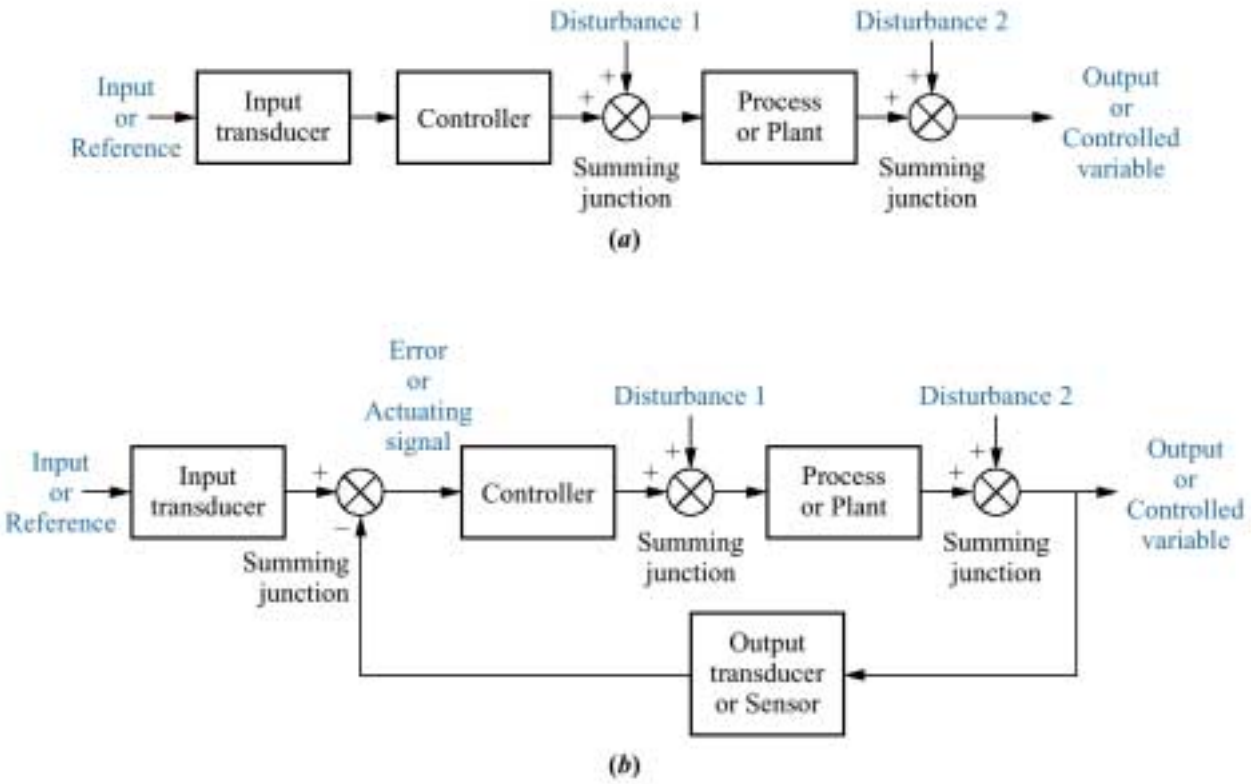


**Figure 1.7**
Computer hard disk drive, showing disks and read/write head

**Figure 1.8**
The search for extraterrestrial life is being carried out with radio antennas like the one pictured here. A radio antenna is an example of a system with position controls.

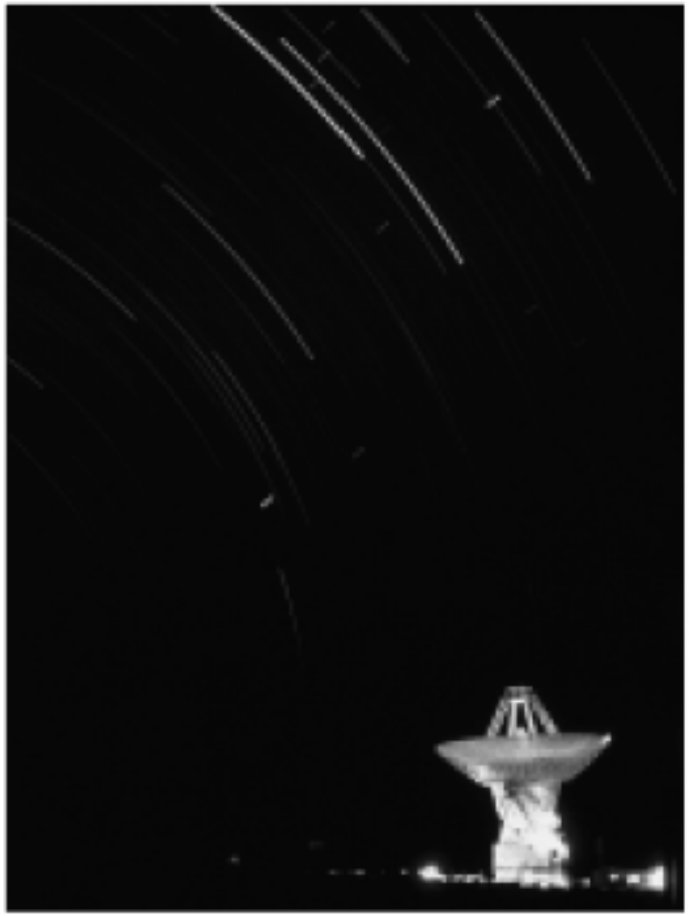
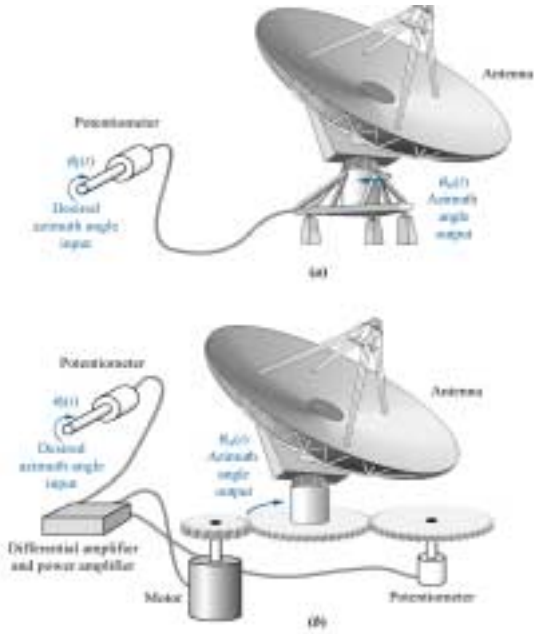
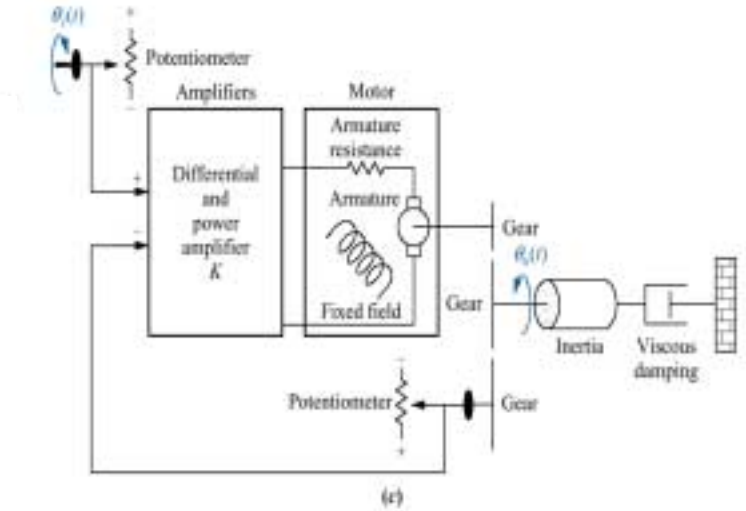


**Figure 1.9**
Antenna azimuth position control system:
**a.** system concept;
**b.** detailed layout;
**c.** schematic;
**d.** functional block diagram



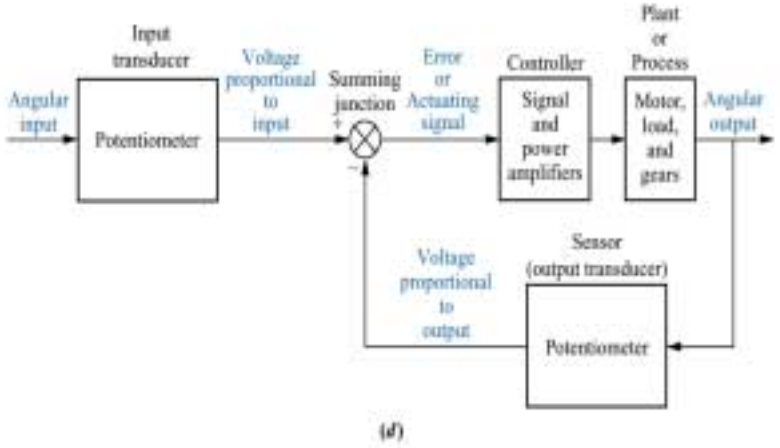



**Figure 1.10**
Response of a position control system showing effect of high and low controller gain on the output response

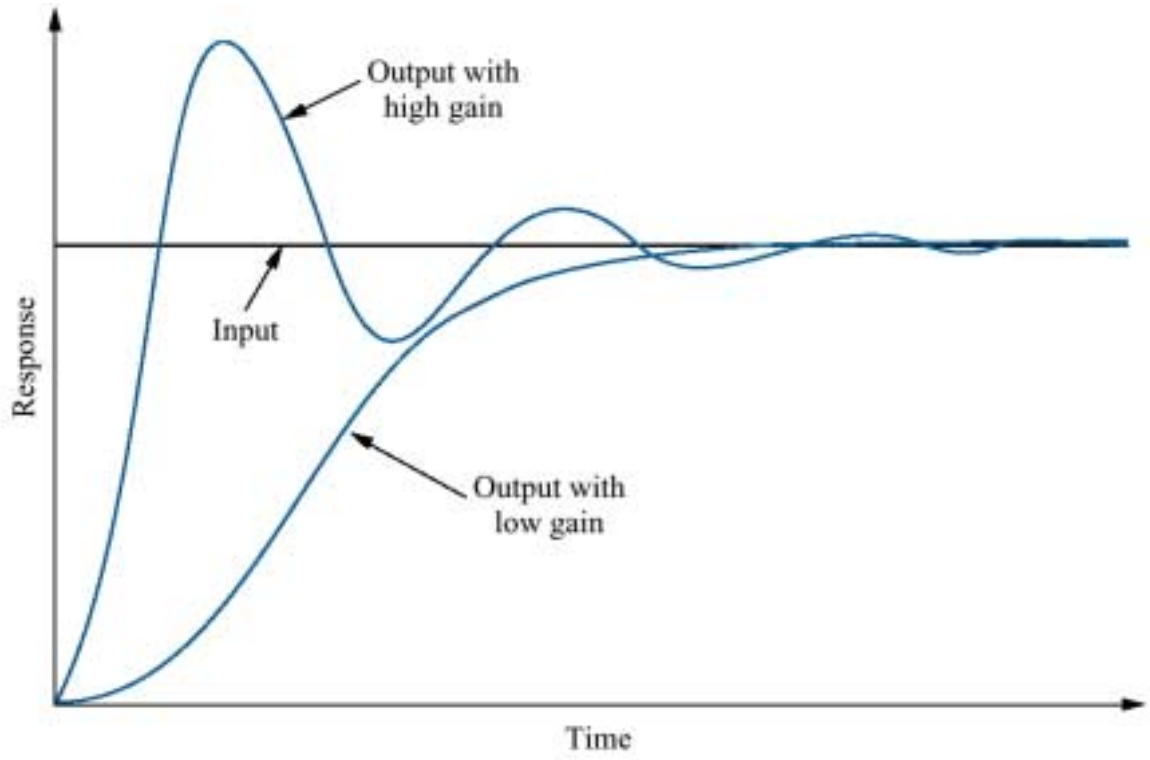


**Figure 1.11**
The control system design process

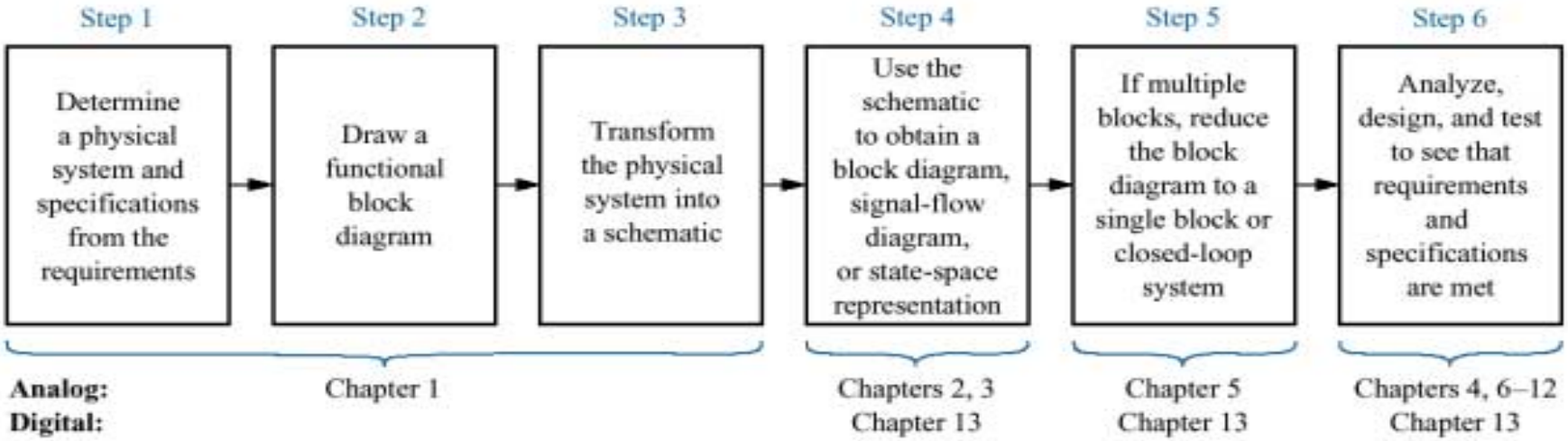


**Figure 1.12**
Equivalent block diagram for the antenna azimuth position control system

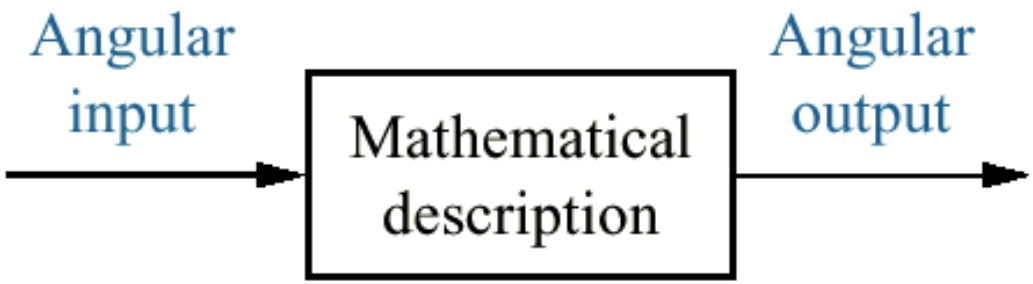


**Figure P1.1**
Potentiometer

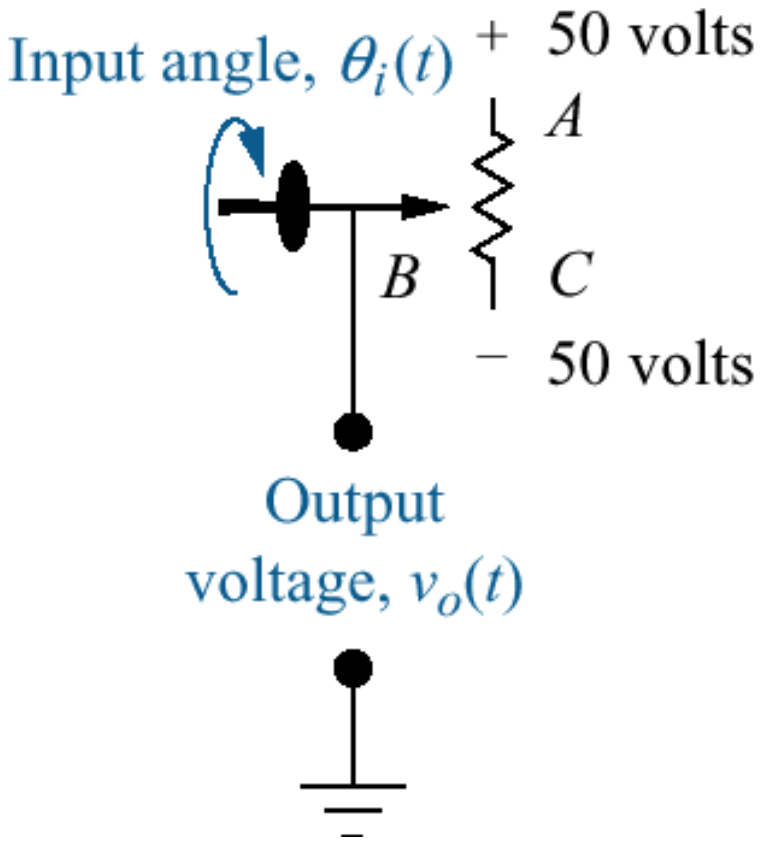


**Figure P1.2**
Aircraft attitude defined

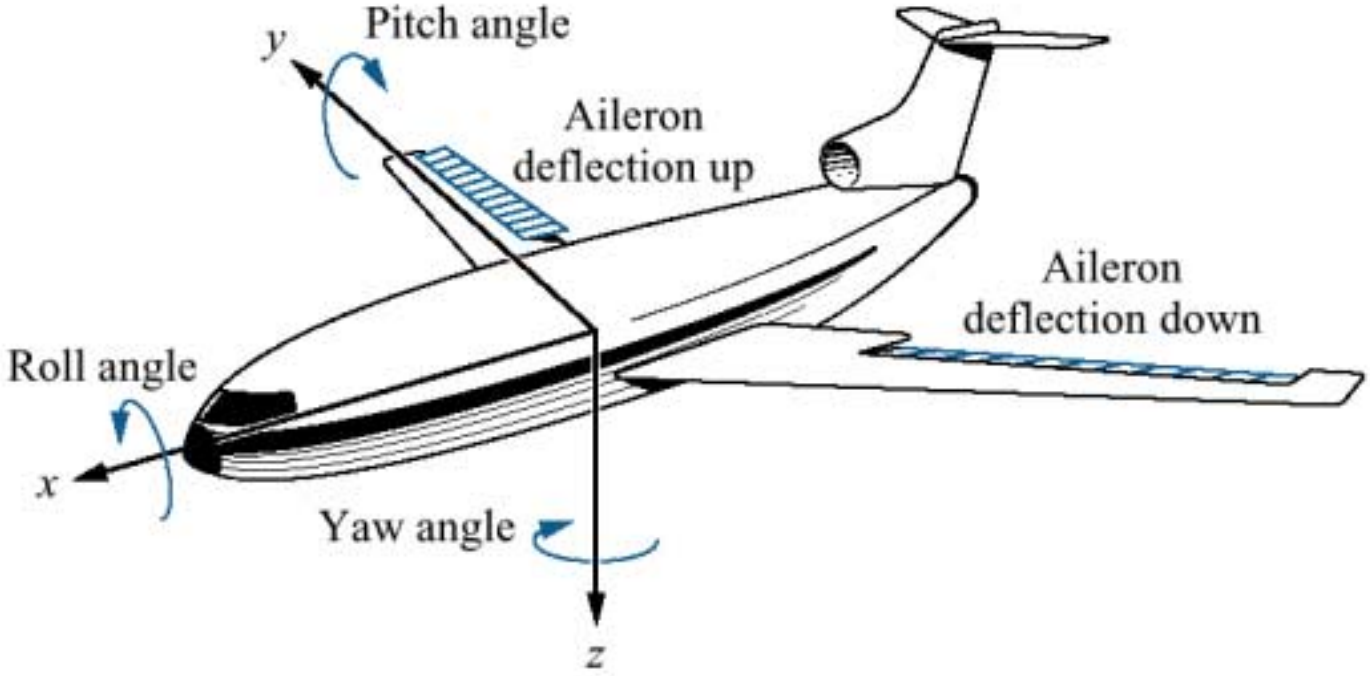


**Figure P1.3**
Winder

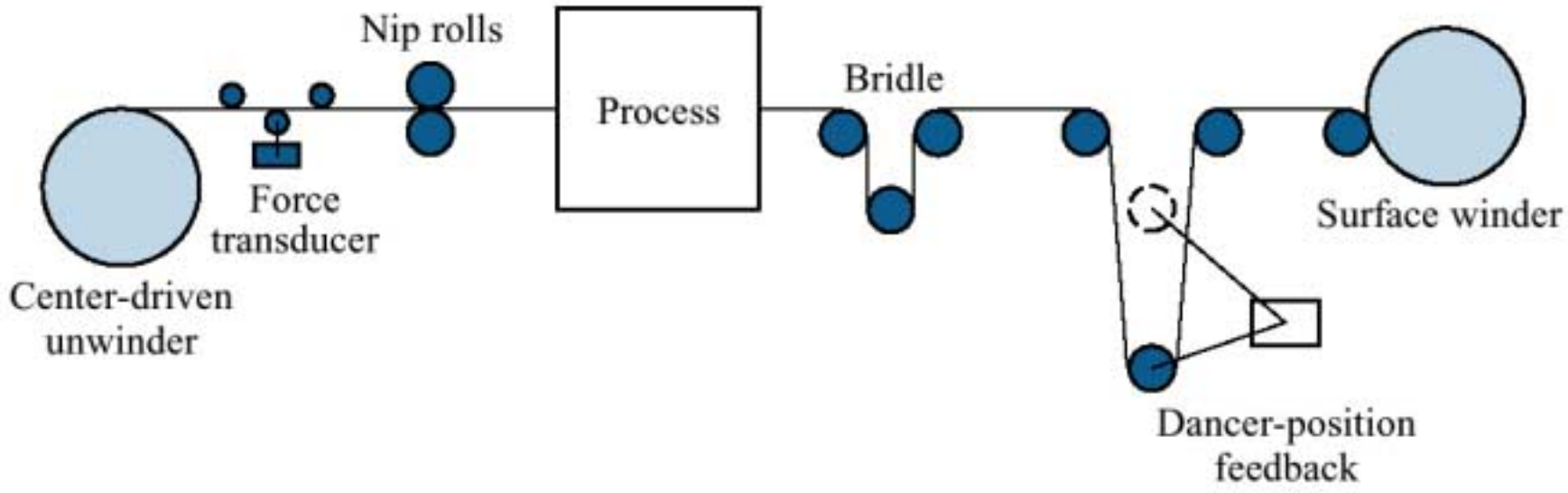


**Figure P1.4**
Control of a nuclear reactor

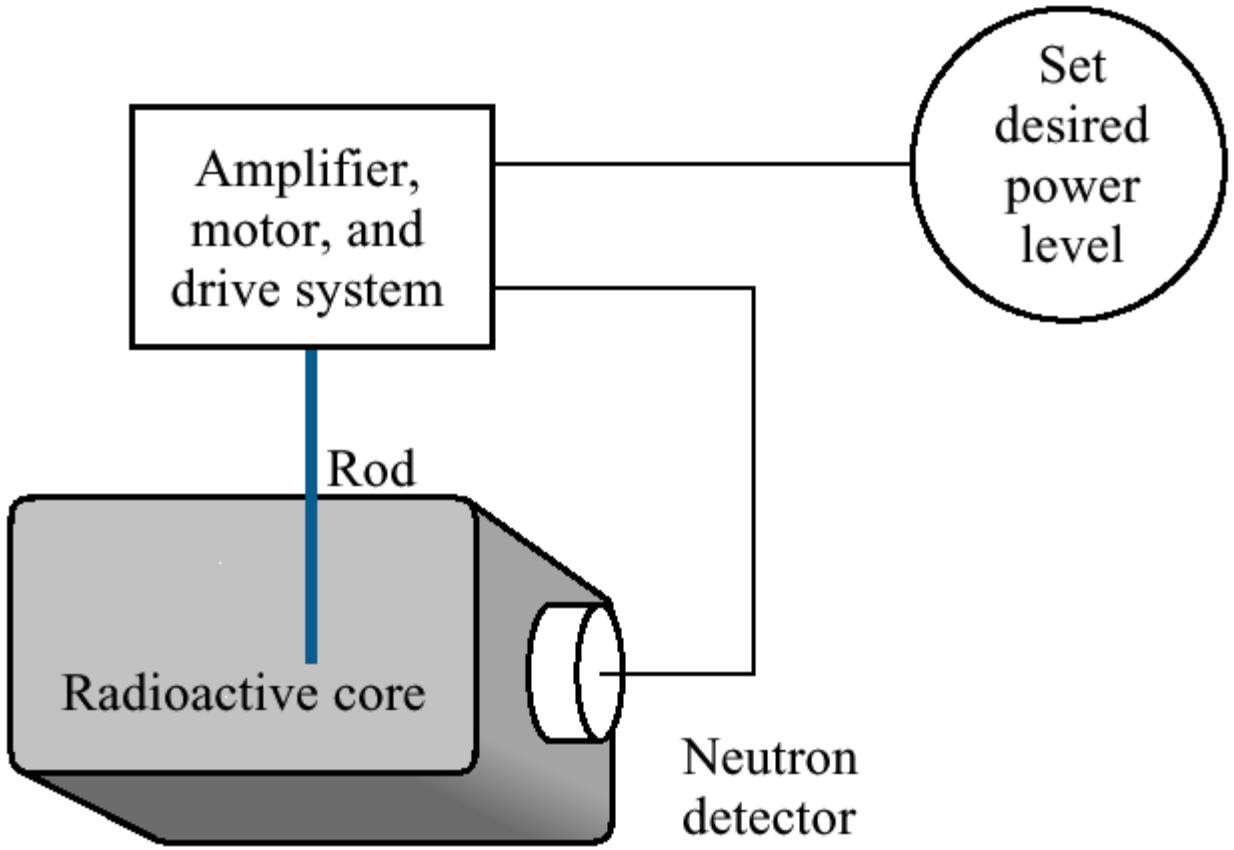


**Fig P1.5**
Grinder system

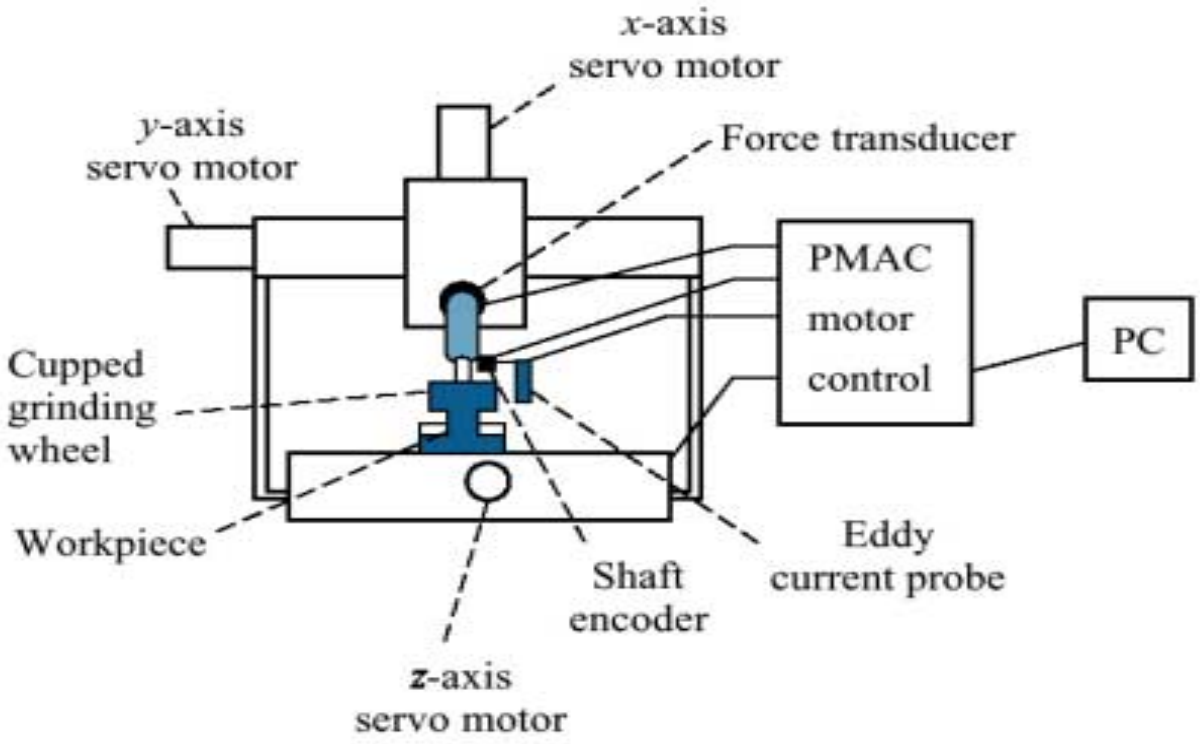


**Figure P1.6**
High-speed proportional solenoid valve

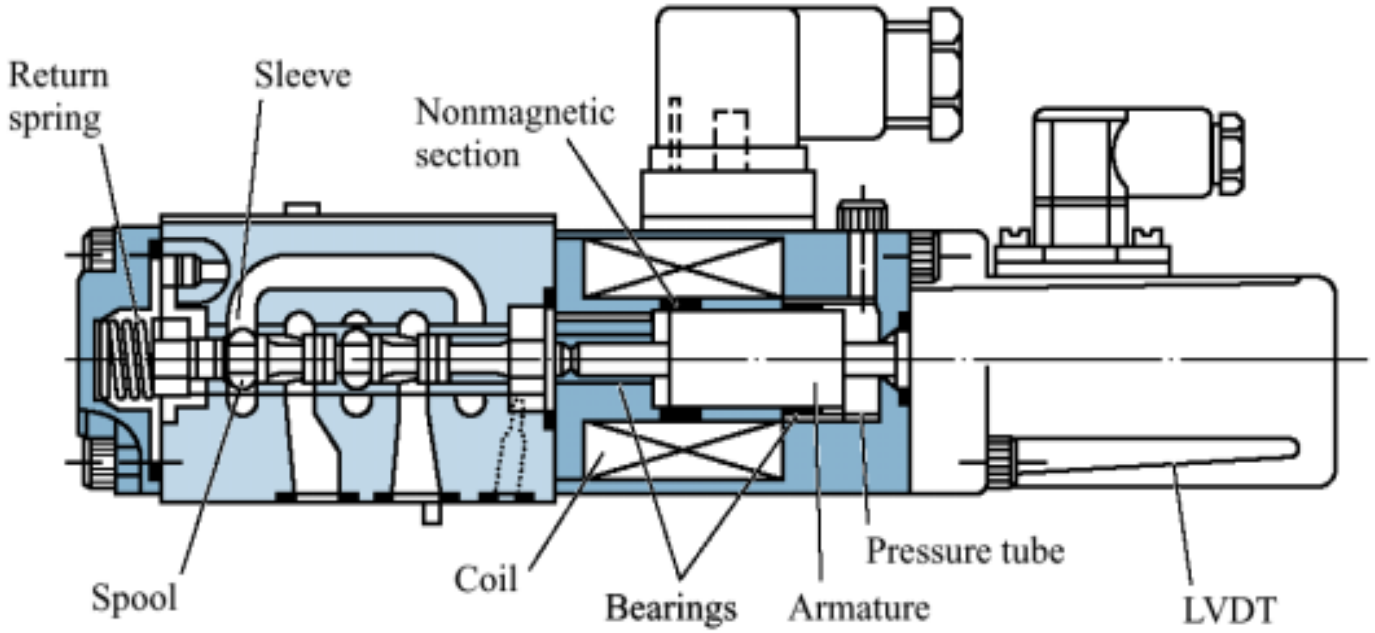


**Figure P1.7**
RL network

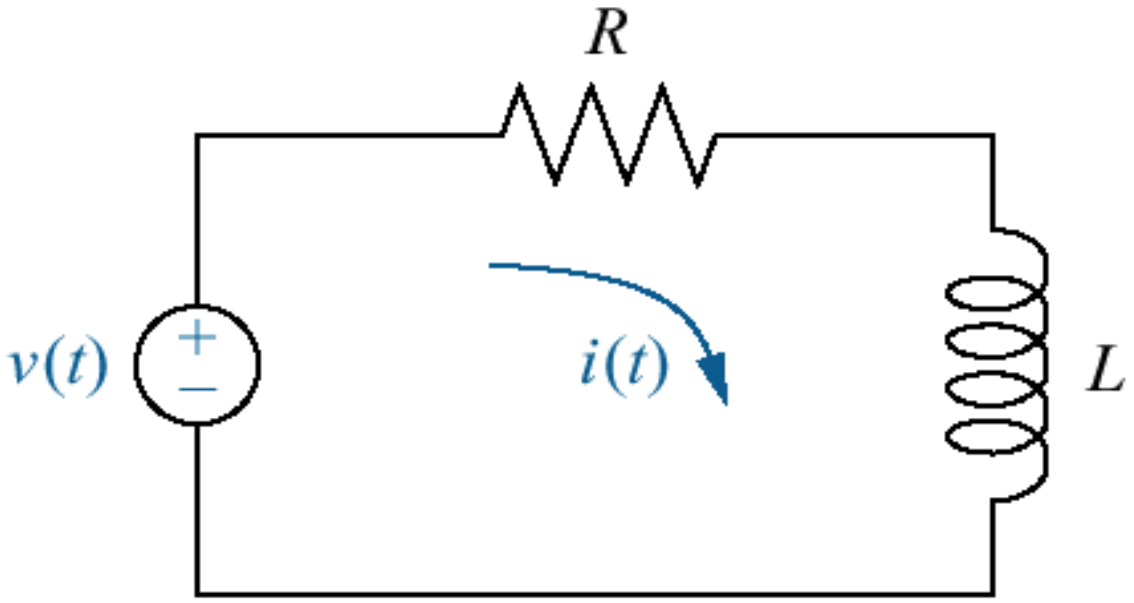


**Figure P1.8**
RLC network

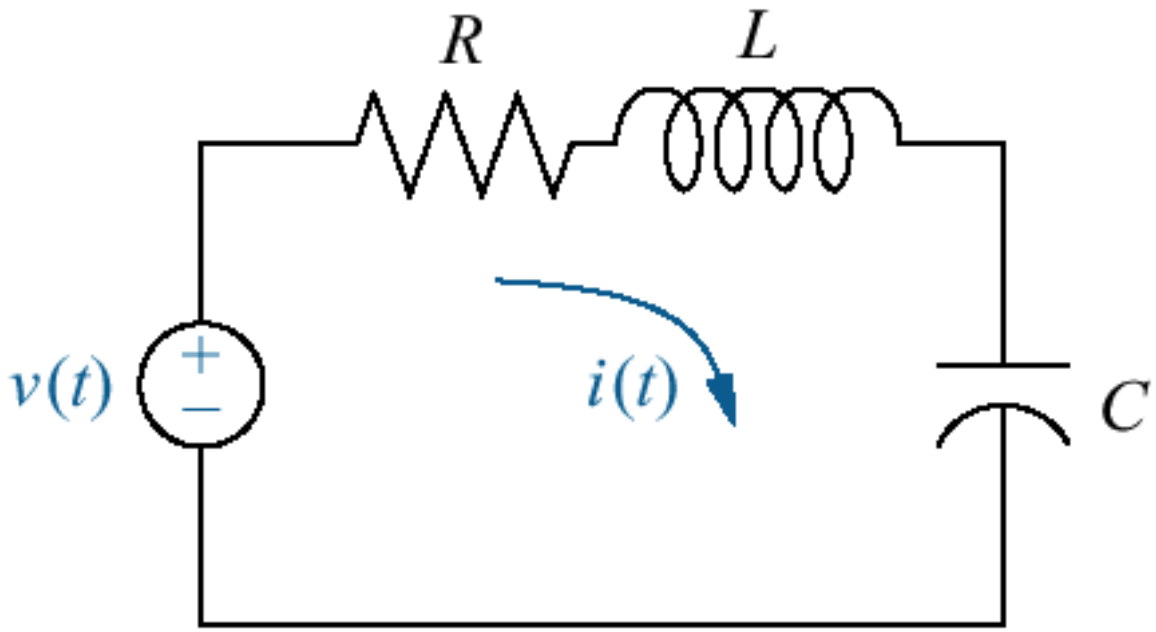


**Figure P1.9**
High-speed rail system showing pantograph and catenary