Ve460/Vm461 Automatic Control Systems
Chapter 1 Introduction

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The main objectives of this chapter are:

1. Define a control system;
2. Explain why control systems are important;
3. Introduce the basic components of a control system;
4. Give some examples of control system applications;
5. Explain why feedback is incorporated into most control systems;
6. Introduce types of control.

Control systems are abundant in modern civilization:

- Automatic assembly lines;
- Space technology;
- Weapon systems;
- Transportation systems;
- Power systems;
- Robotics;
- Micro-Electro-Mechanical Systems (MEMS);
- Nanotechnology,

and many others.

Even the control of inventory, social, and economic systems may be approached from the theory of automatic control.

The basic ingredients of a control system can be described by:

1. Objectives of control;
2. Control-system components;
3. Results or outputs.

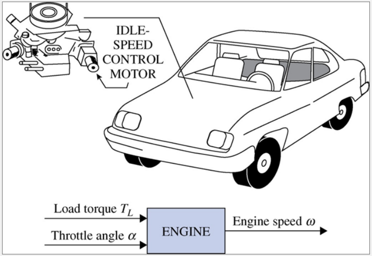
In more technical terms:

u is the **inputs**, or **actuating signals**;

y is the **outputs**, or **controlled variables**.

In general, the objective of the control system is: Control the outputs in some prescribed manner by the inputs through the elements of the control system.

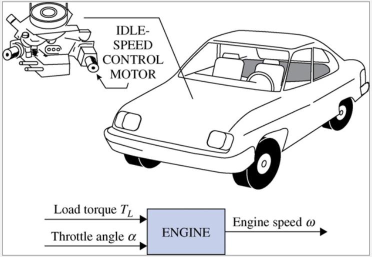
Example 1



Consider the steering control of an automobile:

- Direction of the two front wheels can be regarded as the **controlled variable**, or the output y;
- Direction of the steering wheel is the **actuating signal**, or the input u.

Control system is composed of **the steering mechanism** and **the dynamics of the entire automobile**.



However, if the **objective** is to control the speed, then

- Amount of pressure exerted on the accelerator is the **actuating signal**.
- Vehicle speed is the **controlled variable**.

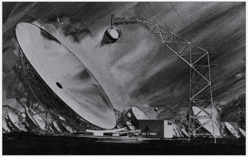
As a whole, we can regard the simplified automobile control system as

- **Two inputs** (steering and accelerator)
- **Two outputs** (heading and speed)

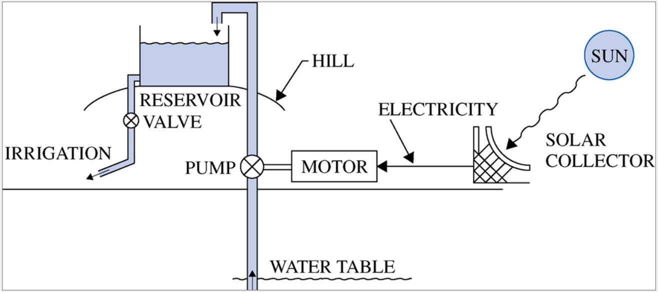
Here the two controls and two outputs are **independent** of each other, but there are systems for which the controls are coupled.

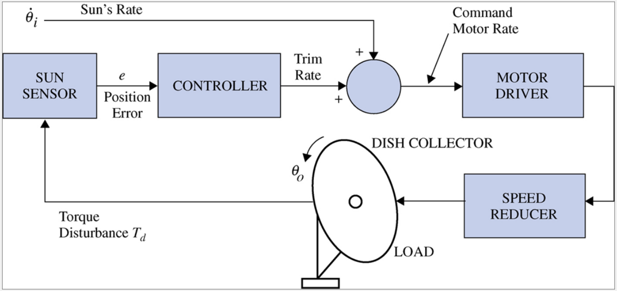
Systems with more than one input and one output are called **multivariable** systems.

Sun-Tracking Control of Solar Collectors



Sun collector dish must track the sun accurately. Therefore, the movement of the collector dish must be controlled by sophisticated control systems.



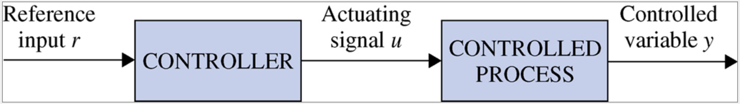


The controller

- Ensures that the tracking collector is pointed toward the sun in the morning and sends a "start track" command;
- Calculates constantly the suns rate for the two axes (azimuth and elevation) of control during the day;
- Uses the sun rate and sensor information as inputs to generate proper motor commands to slew the collector.

Open-Loop Control Systems (Non-feedback Systems)

The idle-speed control system illustrated in the figure below is called an **open-loop control system**.



The elements of an open-loop control system can usually be divided into two parts:

- **The controller**;
- **The controlled process**.

Closed-Loop Control Systems (Feedback Control)

A system with one or more feedback paths such as that just described is called a closed-loop system.

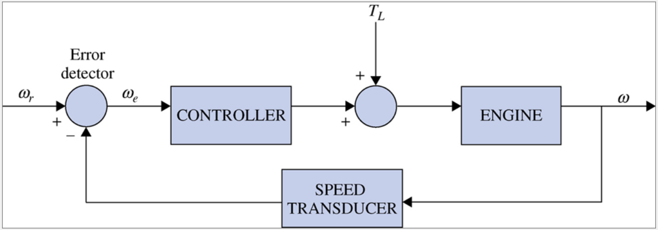
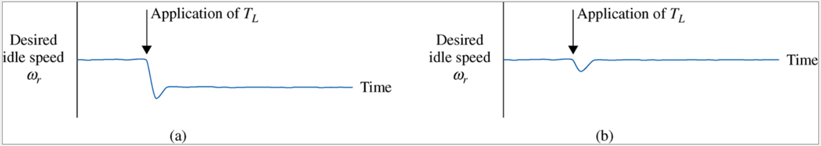


Figure 1.1 Block diagram of a closed-loop idle-speed control system.

- Reference input ω_r sets the desired idling speed;
- Engine speed at idle should agree with ω_r;
- Difference is sensed by the speed transducer and the error detector;
- Controller operates on the difference and provide a signal to adjust the throttle angle to correct the error.



This figure compares the typical performances of open-loop and closed-loop idle speed control systems:

1. Idle speed of the open loop system will drop and settle at a lower value after a local torque is applied;
2. Idle speed of the closed-loop system is shown to recover quickly to the preset value after the application of T_L.

1-2 What are feedback and its effects?

Feedback is used to reduce the error between the reference input and the system output.

Feedback also has effects on such system performance characteristics as stability, bandwidth, overall gain, impedance, and sensitivity.

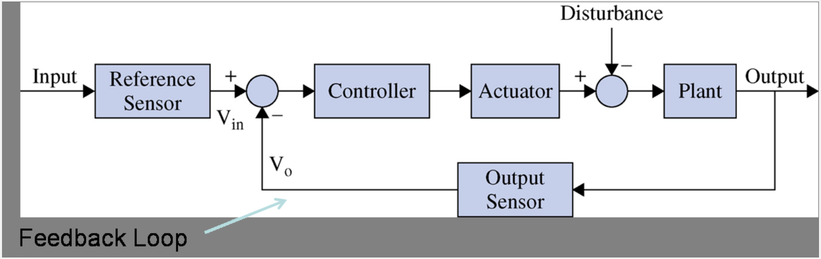
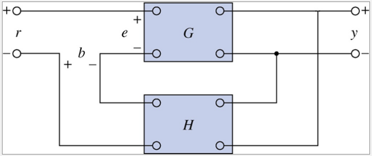


Figure 1.2A general control system.

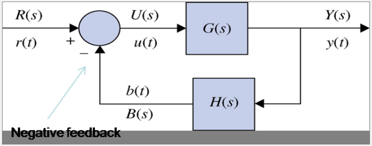
Feedback



- r: the input signal;
- y: the output signal;
- e: the error;
- b: the feedback signal.

Parameters G and H may be considered as constant gains.

$$M = \frac{y}{r} = \frac{G}{1 + GH}.$$



Digital Control System