

Module 1

Introduction to Mechatronics

Fundamentals of Mechatronics (MH501)

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Module Objectives

After this module you will be able to

- Explain the meaning of Mechatronics and its relevance in engineering design
- Know about various applications of mechatronics
- Explain what is a system
- Describe open loop and closed loop systems
- Compare between traditional and mechatronics based design approach

History

- “Mechatronics” term coined by engineer Tetsura Mori in 1969 at Yasakawa Electric Corp.
- Upto 1980 mechatronics meant only combination of electronics and mechanical engineering
 - Computing technology added later with development of computers

Bird's Eye View of Mechatronics

- Multidisciplinary
 - Electronics
 - Mechanical
 - Software
 - Control
 - Systems Design
- Examples include, modern automobiles, spacecrafts, marine vessels, robots, factory automated systems, etc.

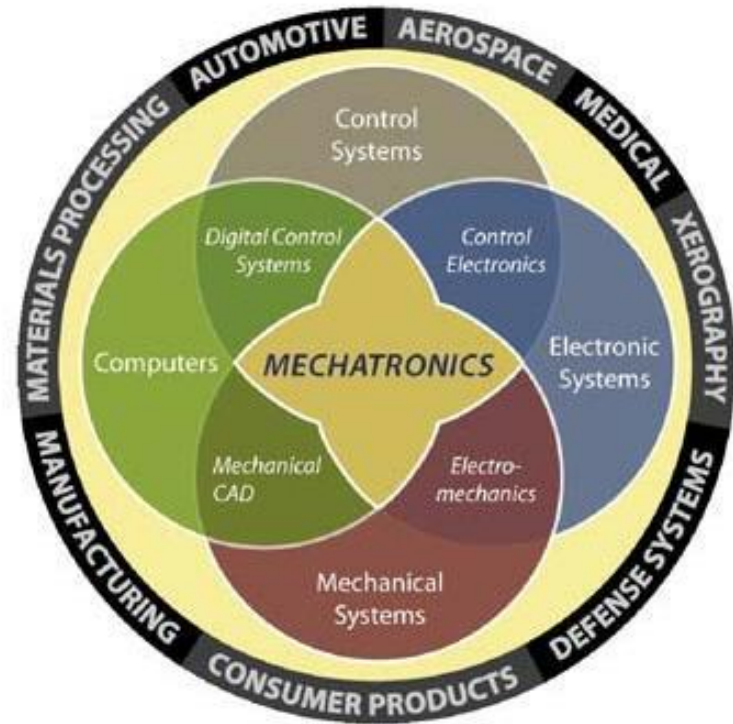


Fig. Ref. : Rensselaer Polytechnic Institute

Examples of Mechatronics Systems

A Document Scanner

- Quiz : List the components of a document scanner and describe how that works using neat sketches

Scanner Types



Flatbed scanner



Sheetfed scanner



Drum scanner



Handheld scanner

Flatbed Scanner

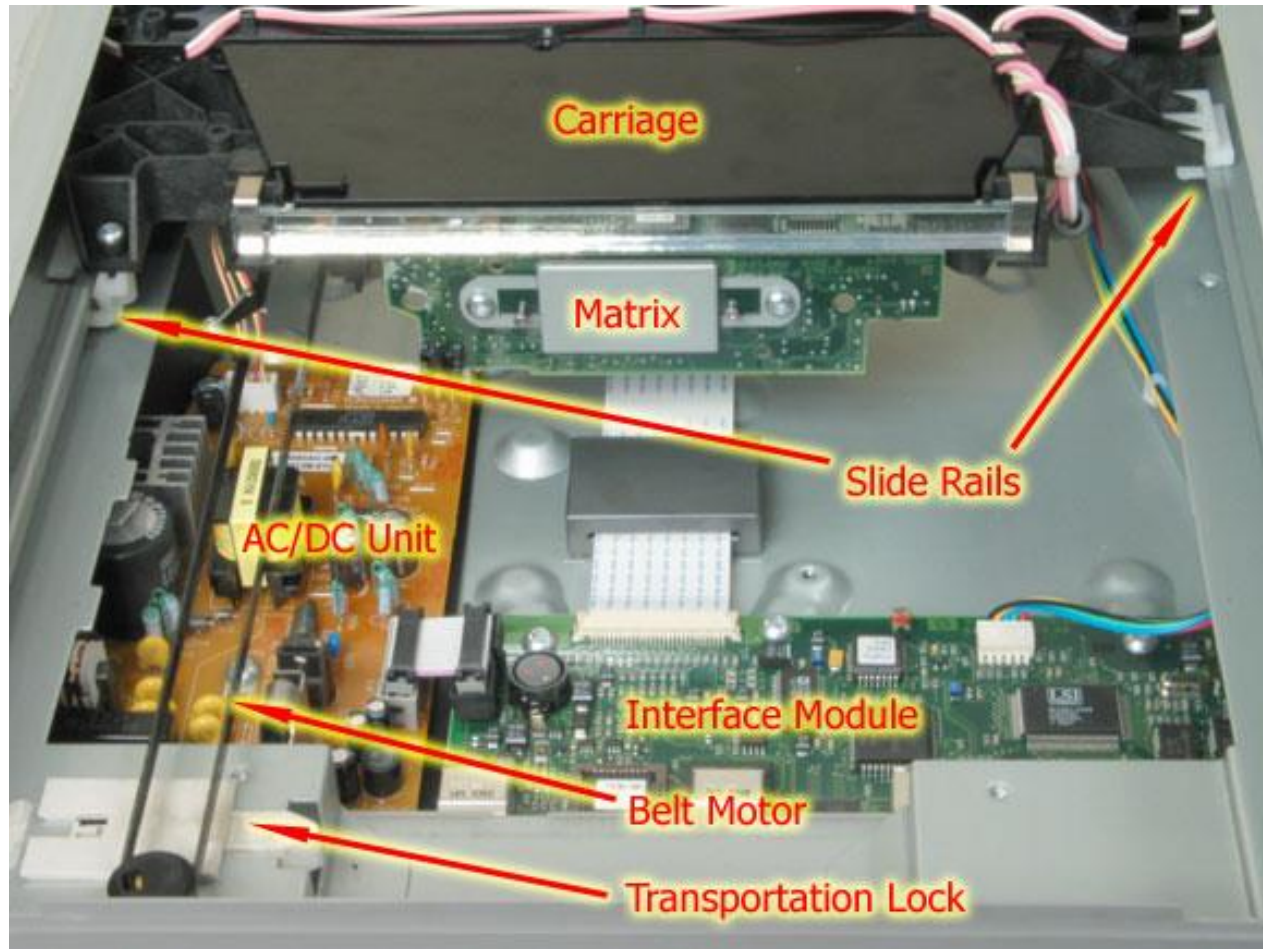


Components of Scanner

- Scanner head
 - Fluorescent lamp
 - Transformer
 - CCD sensor
 - Mirror
 - Lens
 - Filters
- Drive system
 - Stepper motor
 - Belt
- Control circuitry
- Interface ports



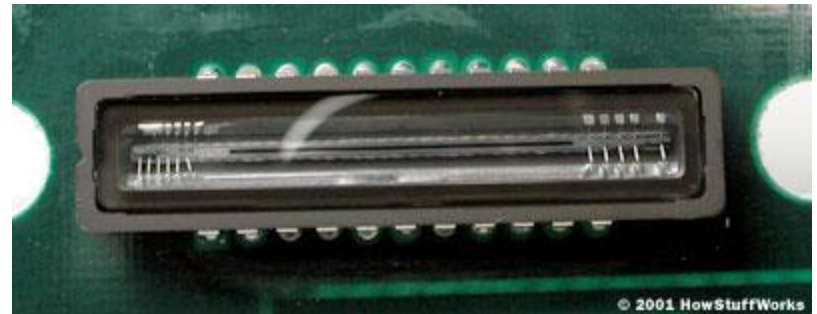
Components of Scanner – Contd.



Components of Scanner – Contd.

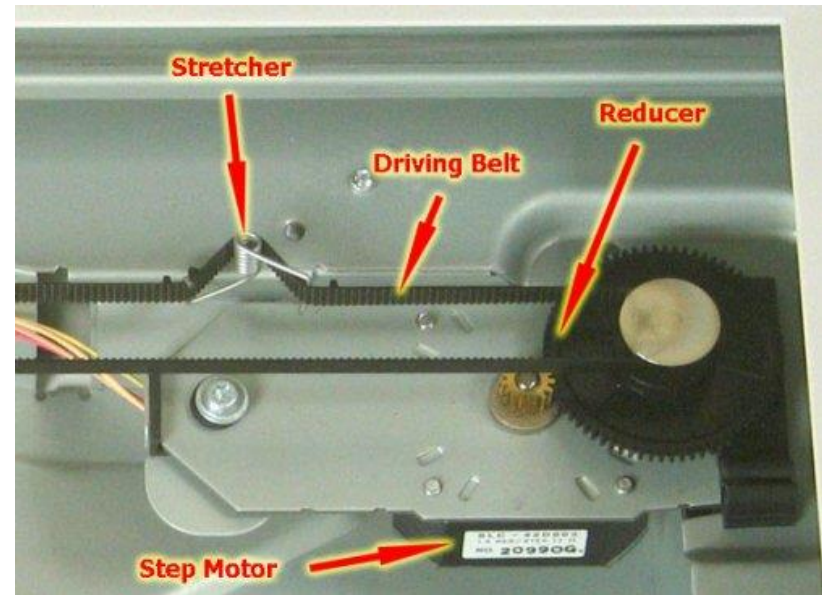
Charge Coupled Device (CCD)

- Photons are converted into electrons
- Array of p-doped MOS capacitors (pixels) sense light
 - High intensity leads to more charge
- Distribution of charge represents image



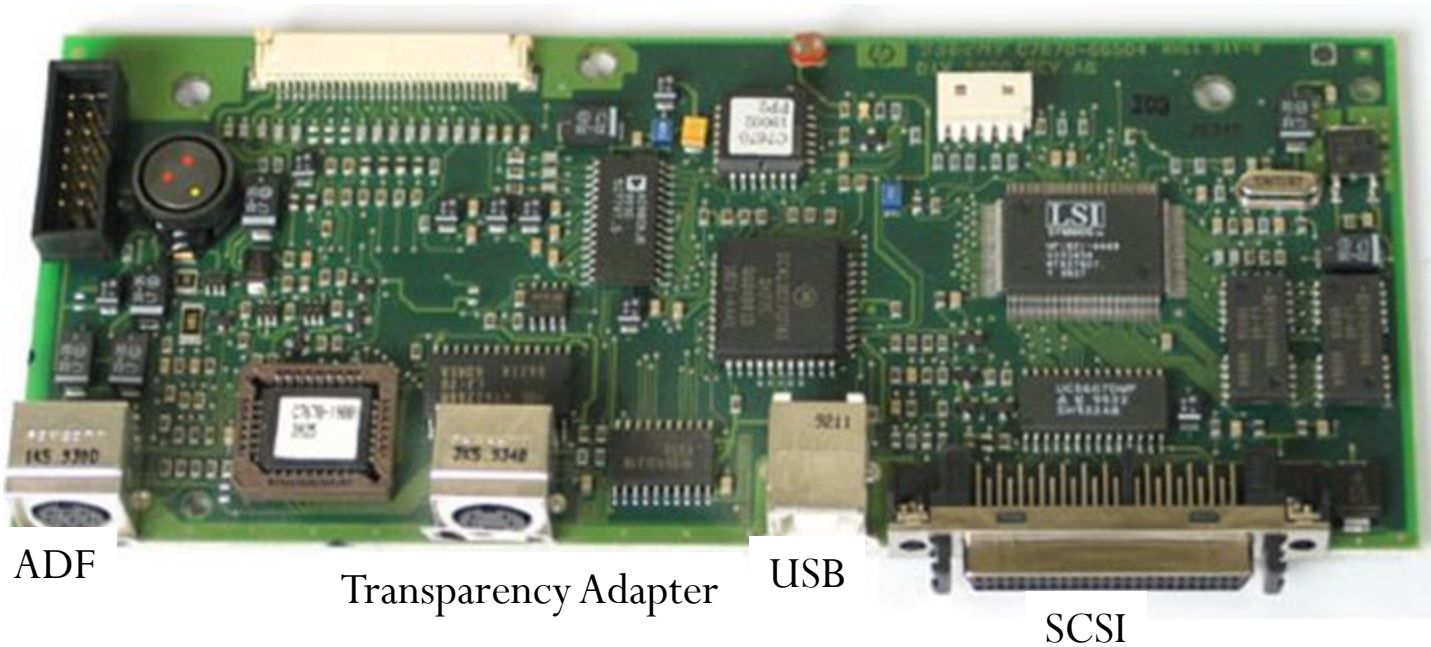
CCD Array

Components of Scanner - Contd.



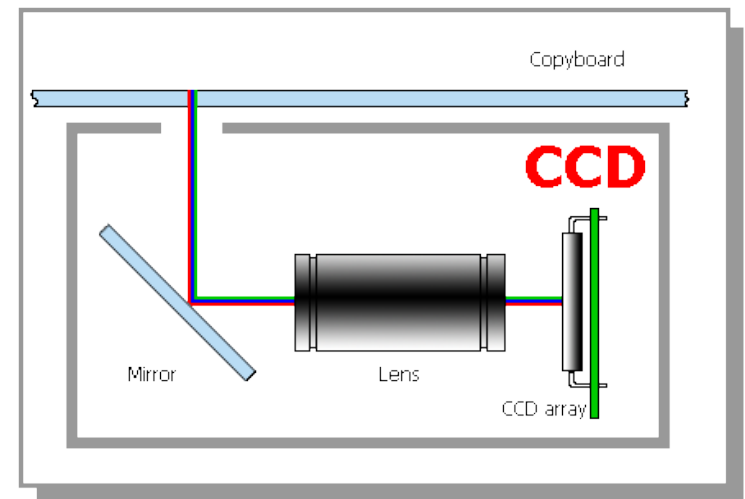
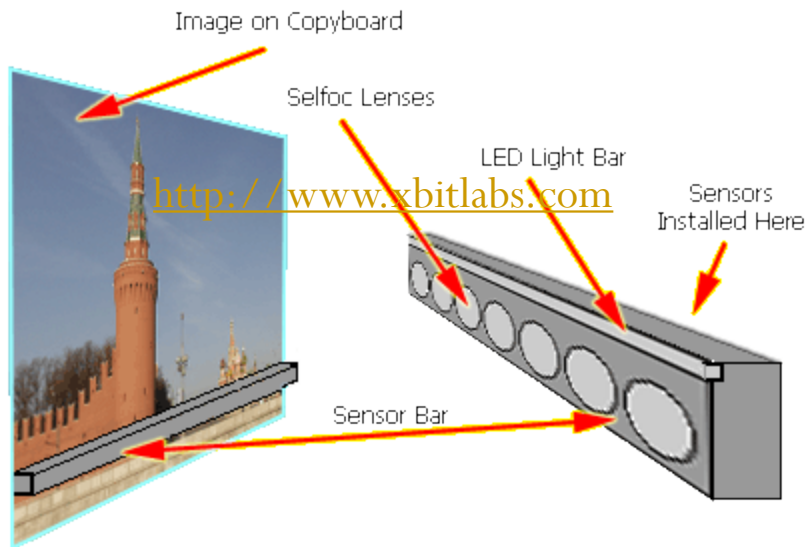
Stepper Motor and belt drive

Components of Scanner - Contd.



Interface Controller

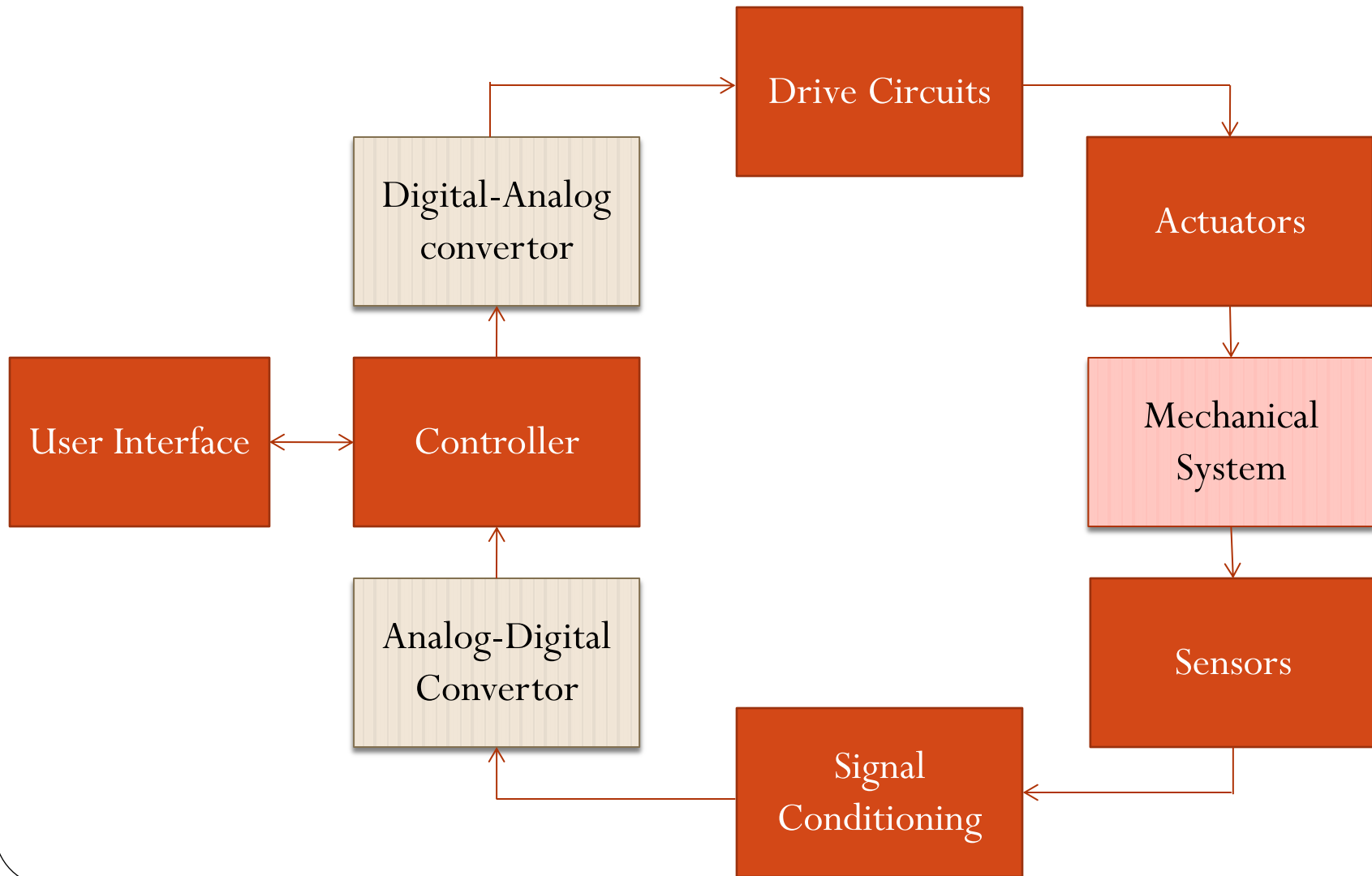
Overall Working of Flatbed Scanner



Parts of a Mechatronics System

- Mechanical System
 - Moving parts like drives, pulleys, gears, mechanisms, etc.
- Electronic and Electrical System
 - Microcontroller, analog-digital and digital-analog converters, sensors, actuators, etc.
- Information System
 - Software
- User Interface

Typical Components of Mechatronics System

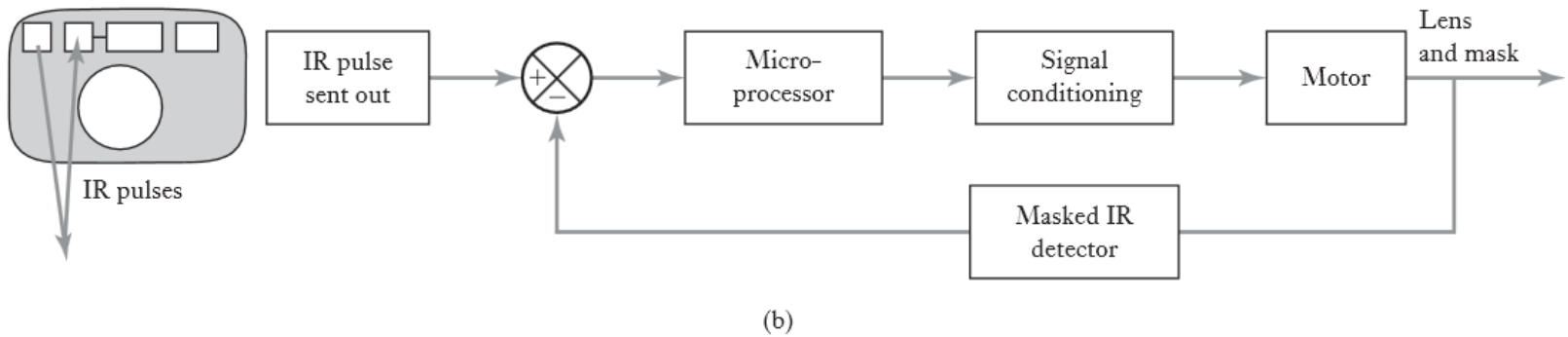
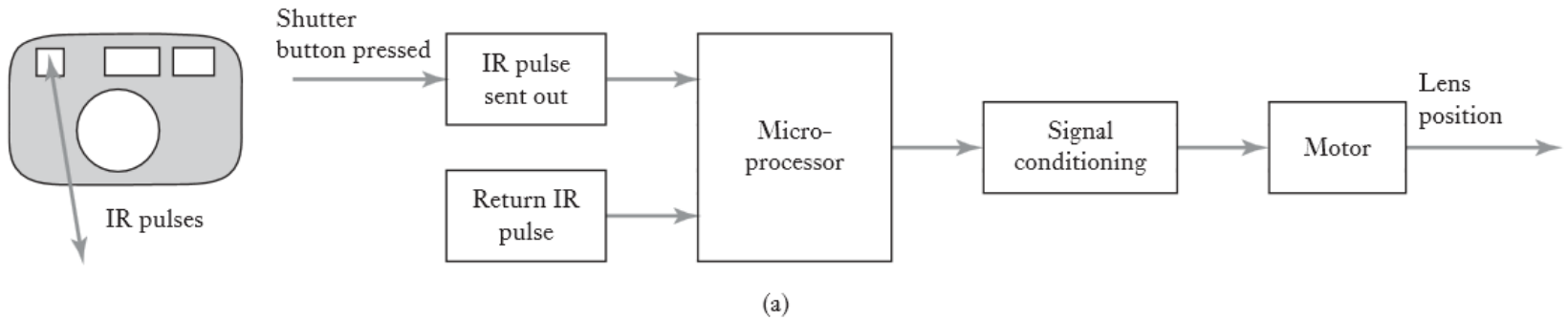


Some Other Examples of Mechatronic Systems

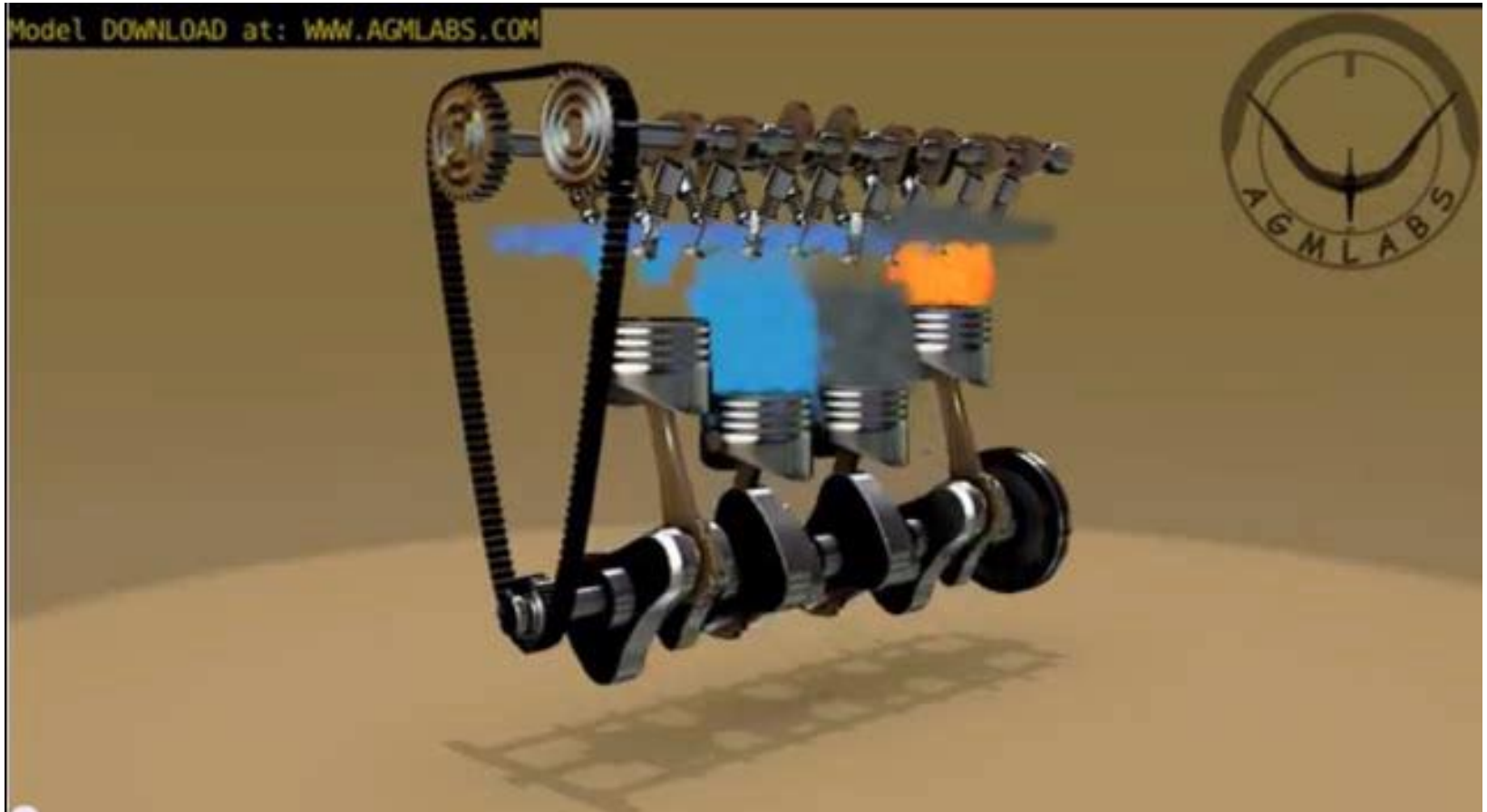
- Digital Camera



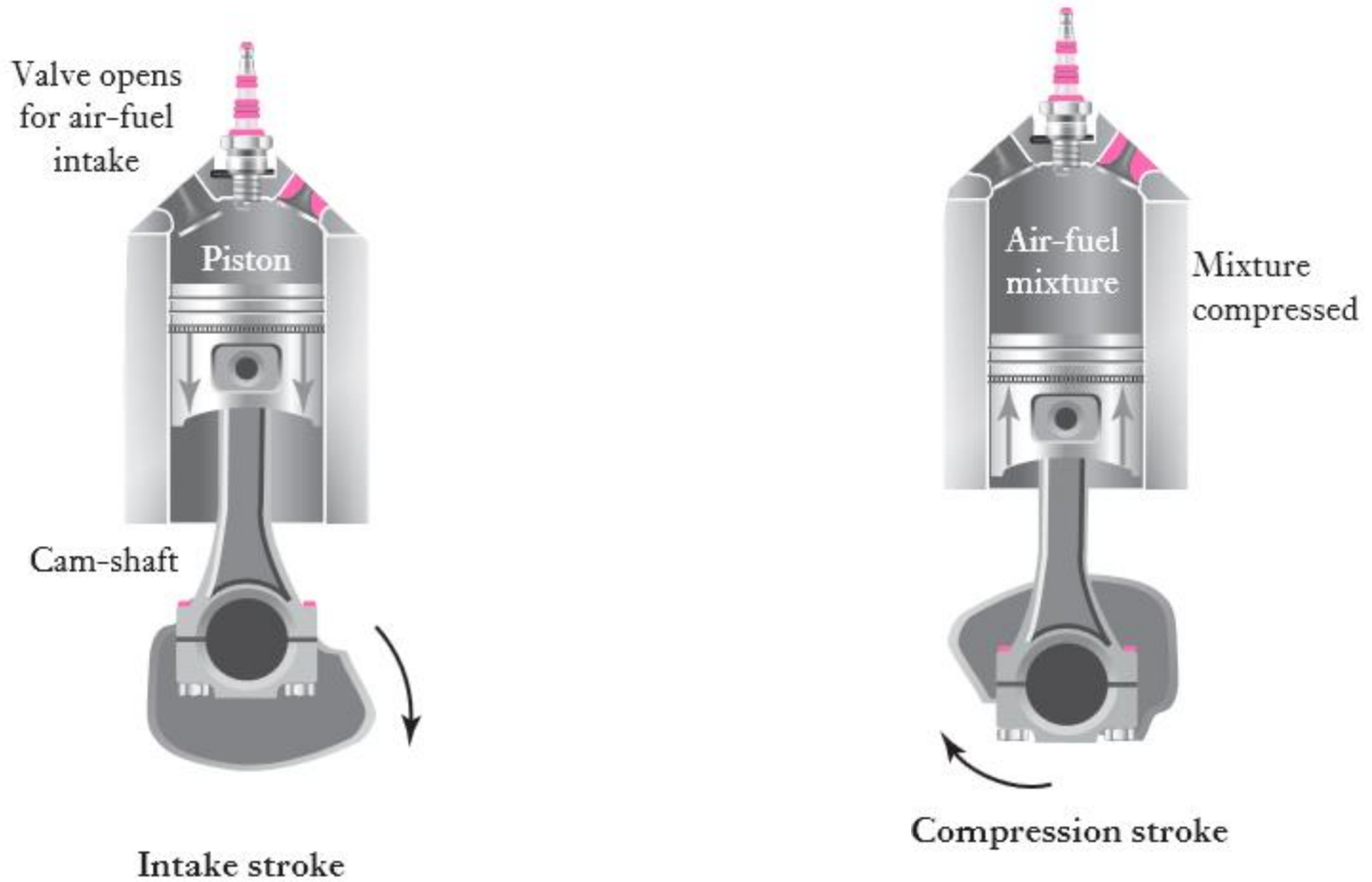
Autofocus



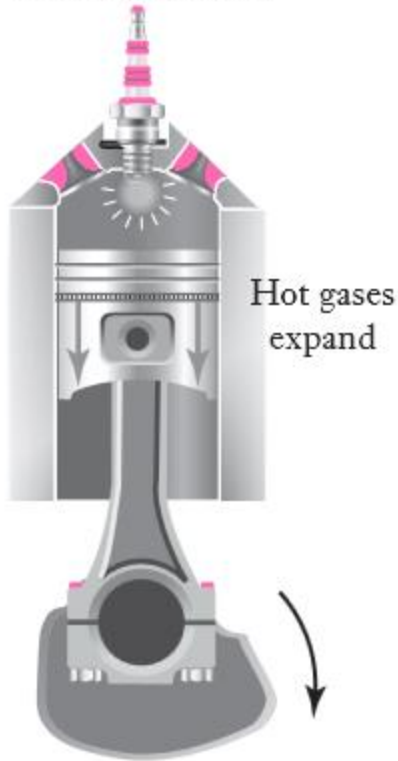
Engine Management System



Engine Management System



Spark for ignition

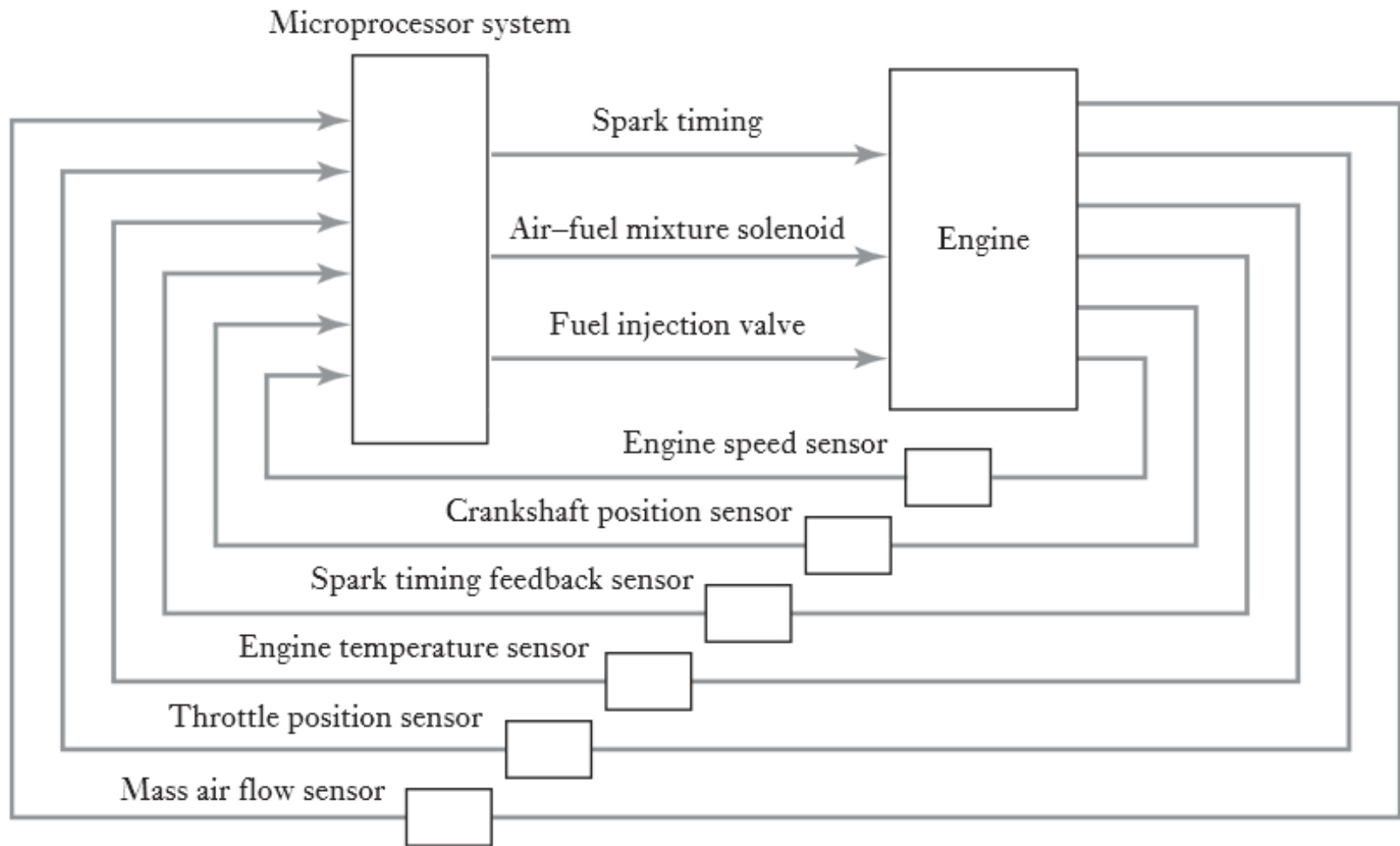


Power stroke

Valve opens to vent exhaust gases



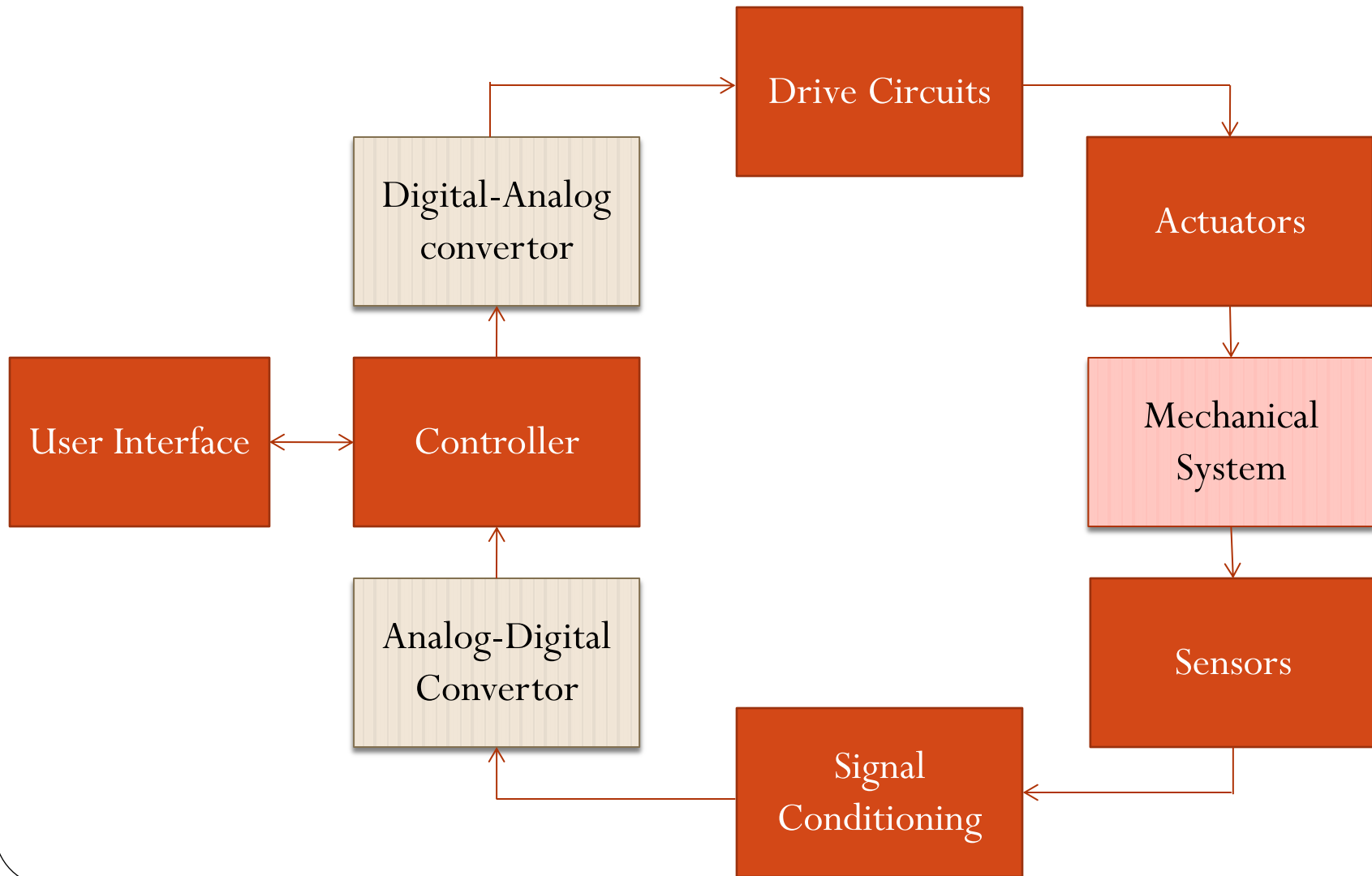
Exhaust stroke



Parts of a Mechatronics System

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- Information System
 - Software

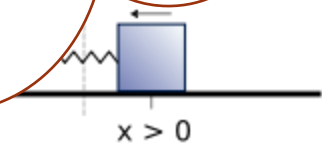
Typical Components of Mechatronics System



System

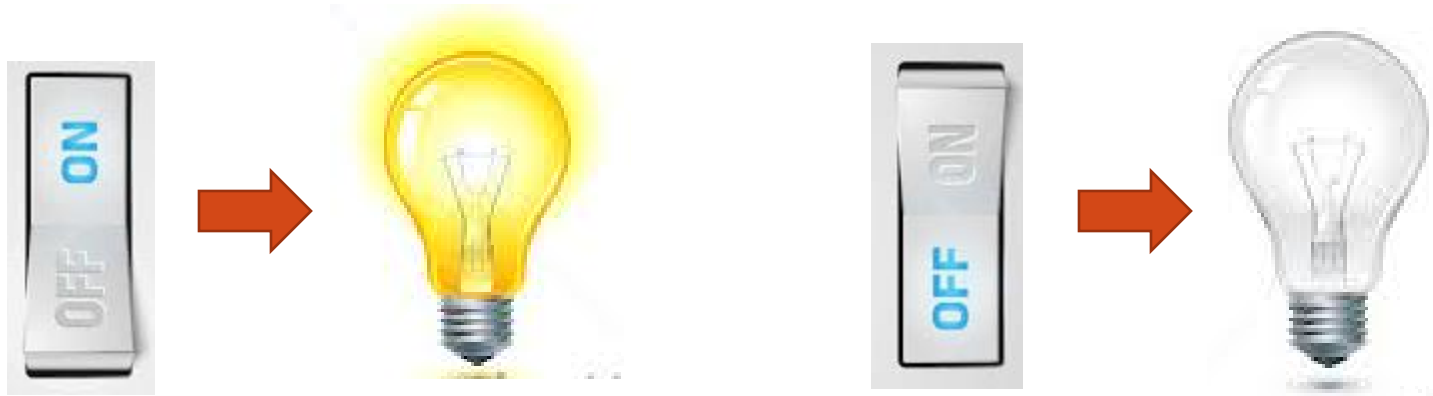
- A system can be thought as box or block diagram
 - Having an input and correspond output
- Inputs and outputs of system
 - not what goes inside the sys

We don't care about internal physics such as grain structure of spring material or molecular phenomenon

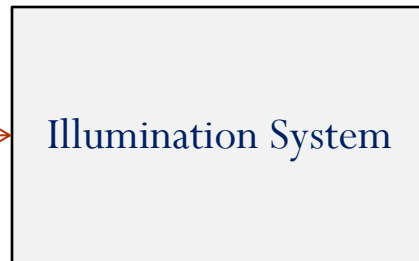


$$\text{Output force} = \text{Spring Stiffness} \times \text{Input Displacement}$$

System : Room Illumination

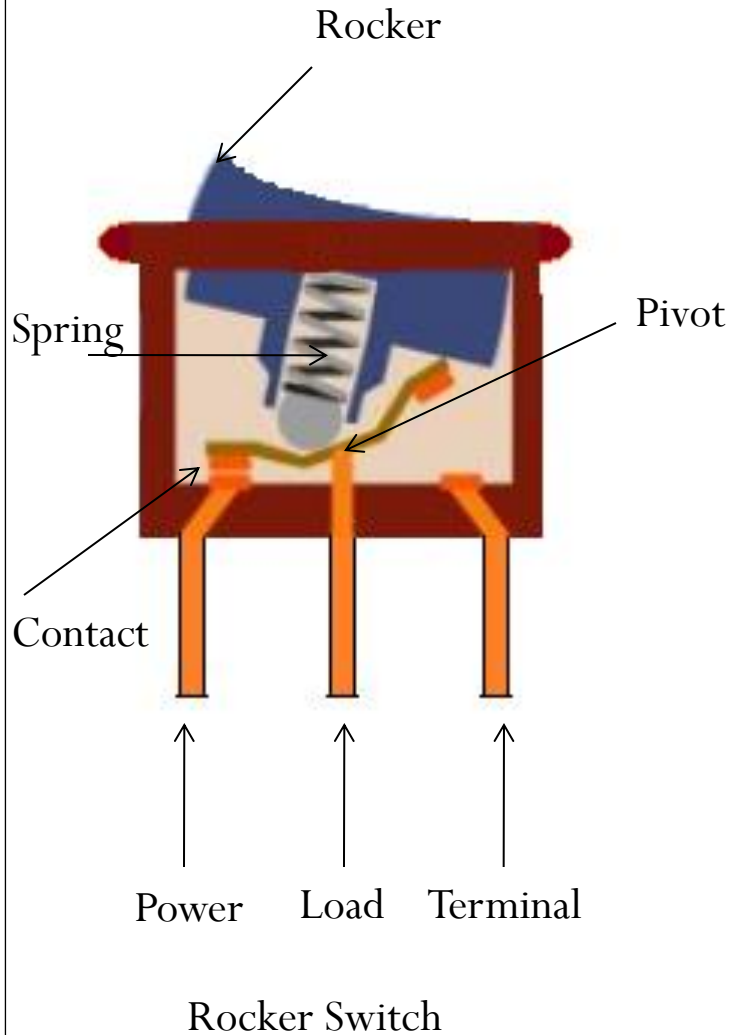


Input
Switch position ON or OFF

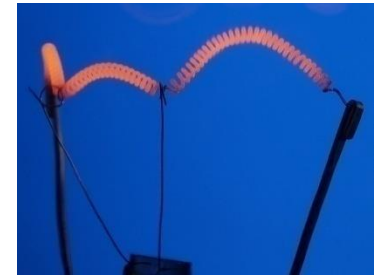


Output
Glow or Darkness

Physical Components of Illumination System



Light bulb with inert gas

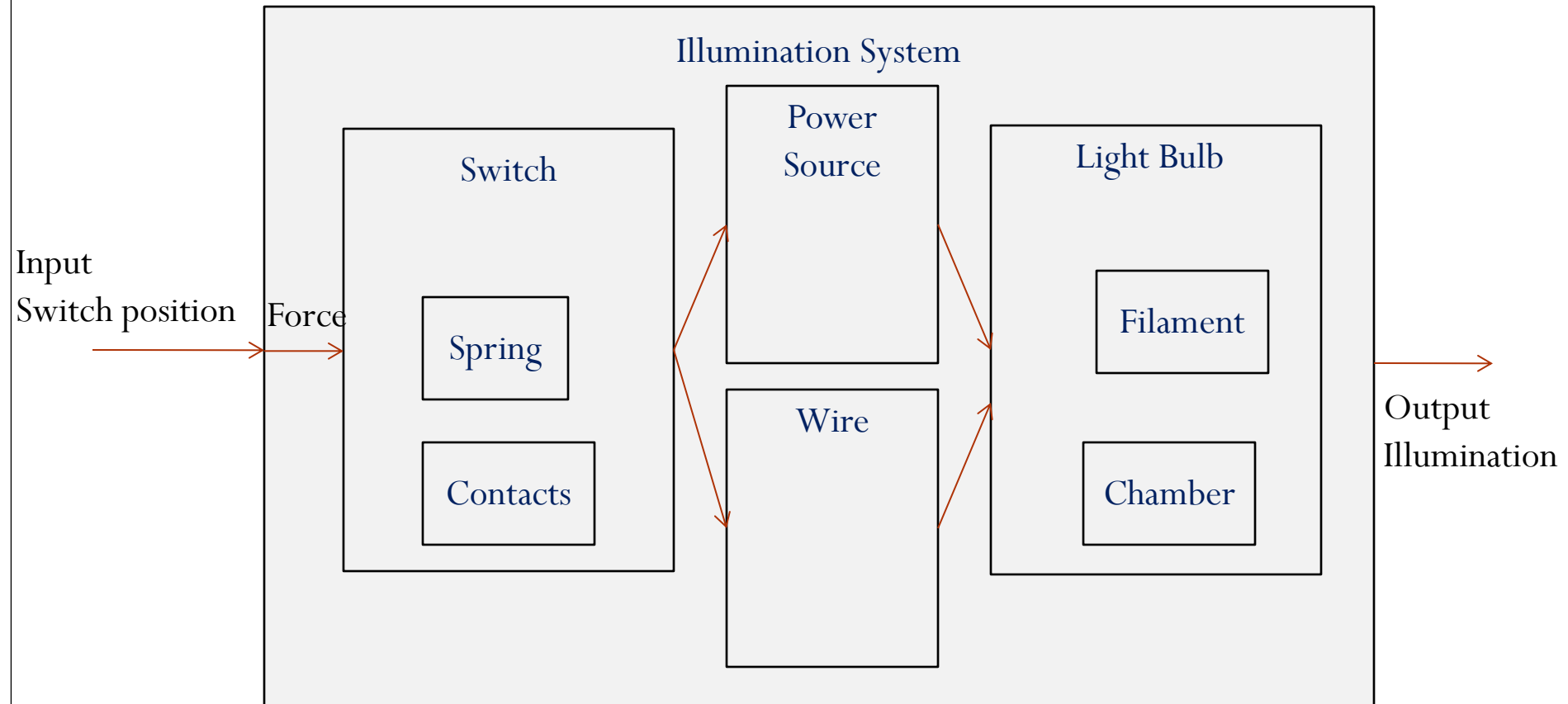


Filament



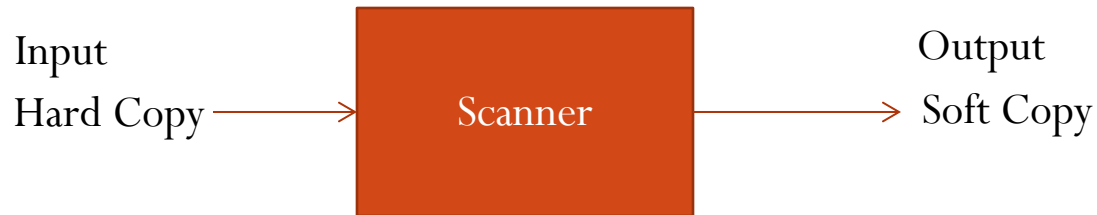
Power System

Subsystems of Illumination System

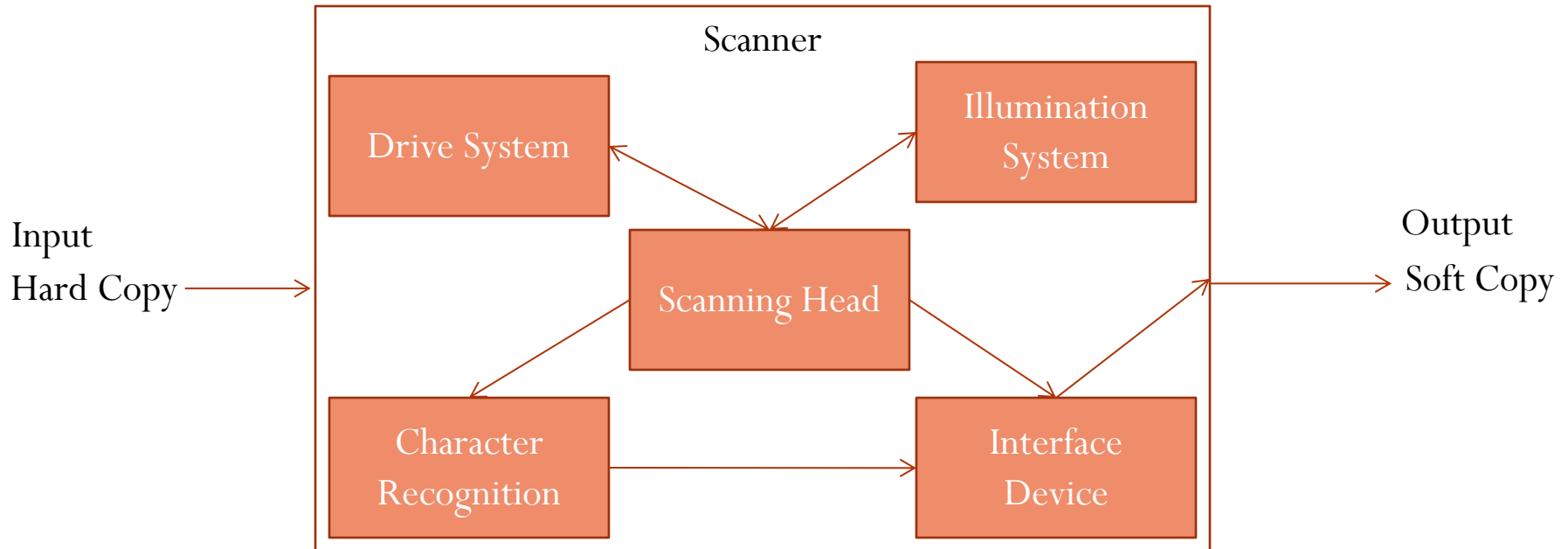


Mechatronics System Example

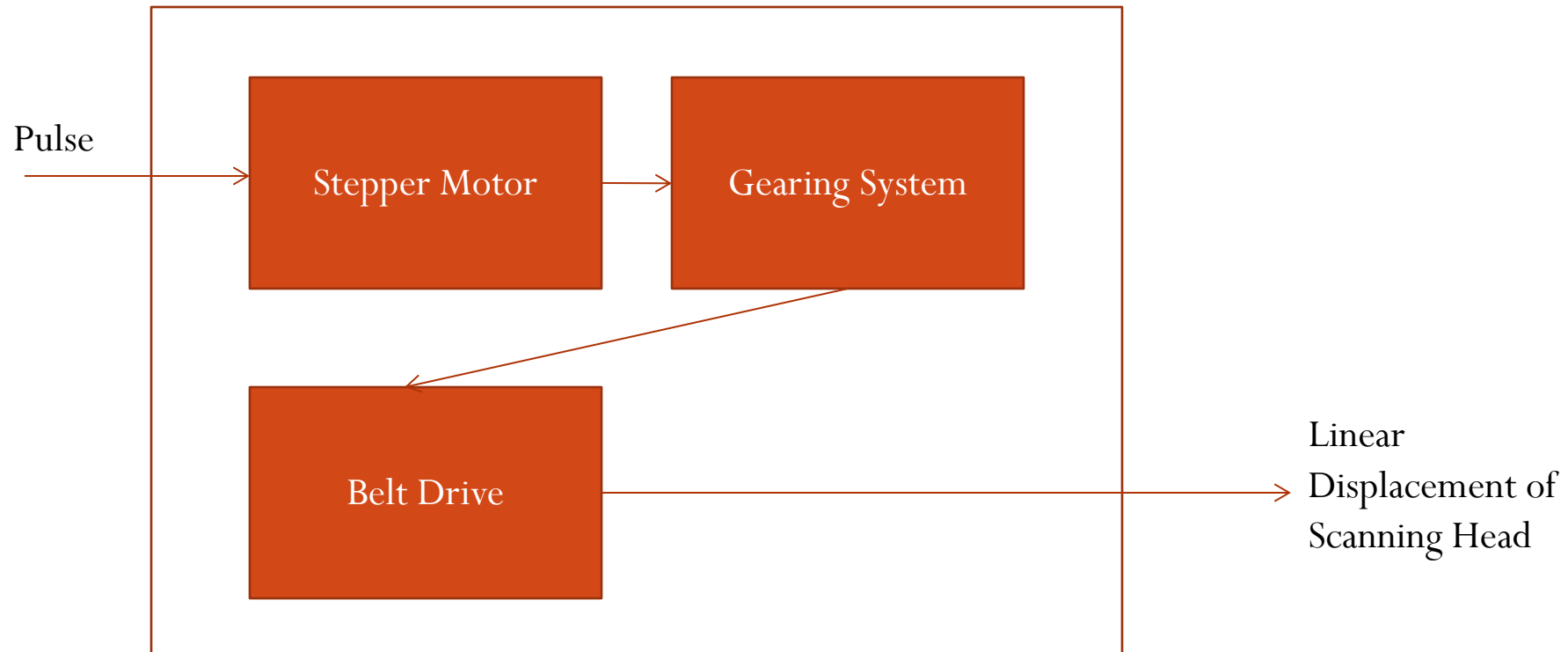
Scanner Example Revisited



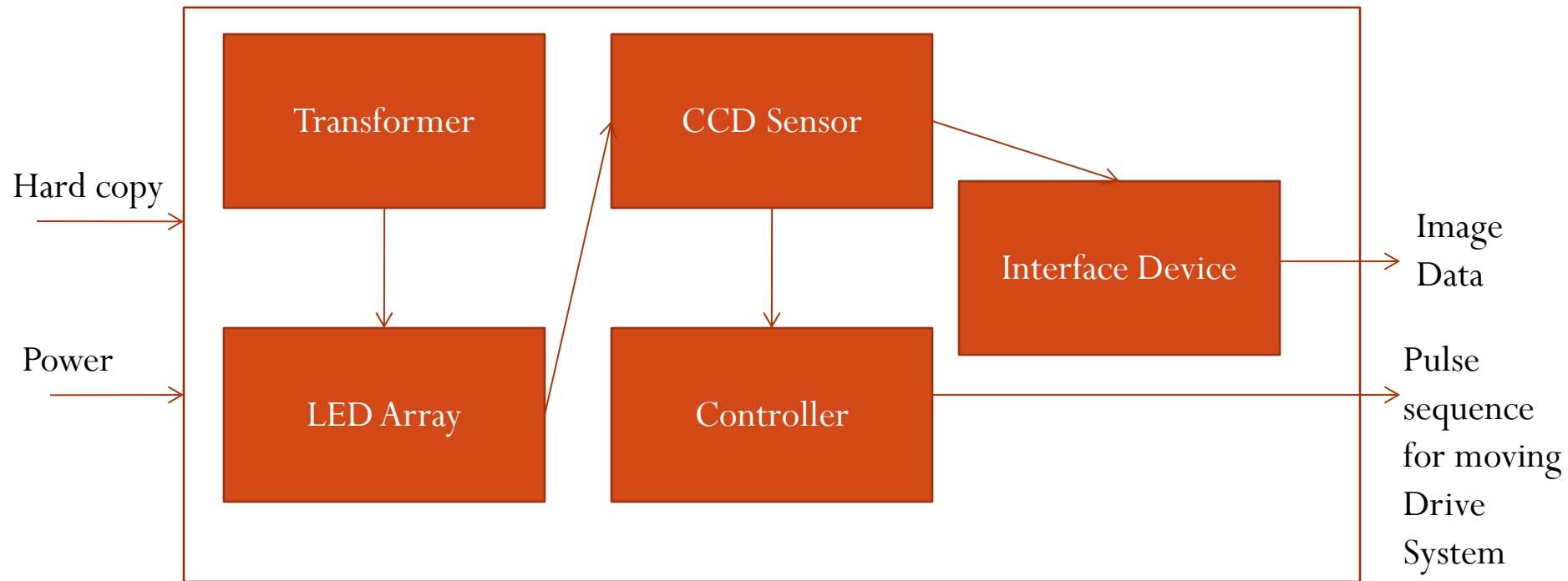
Subsystems of Scanner System



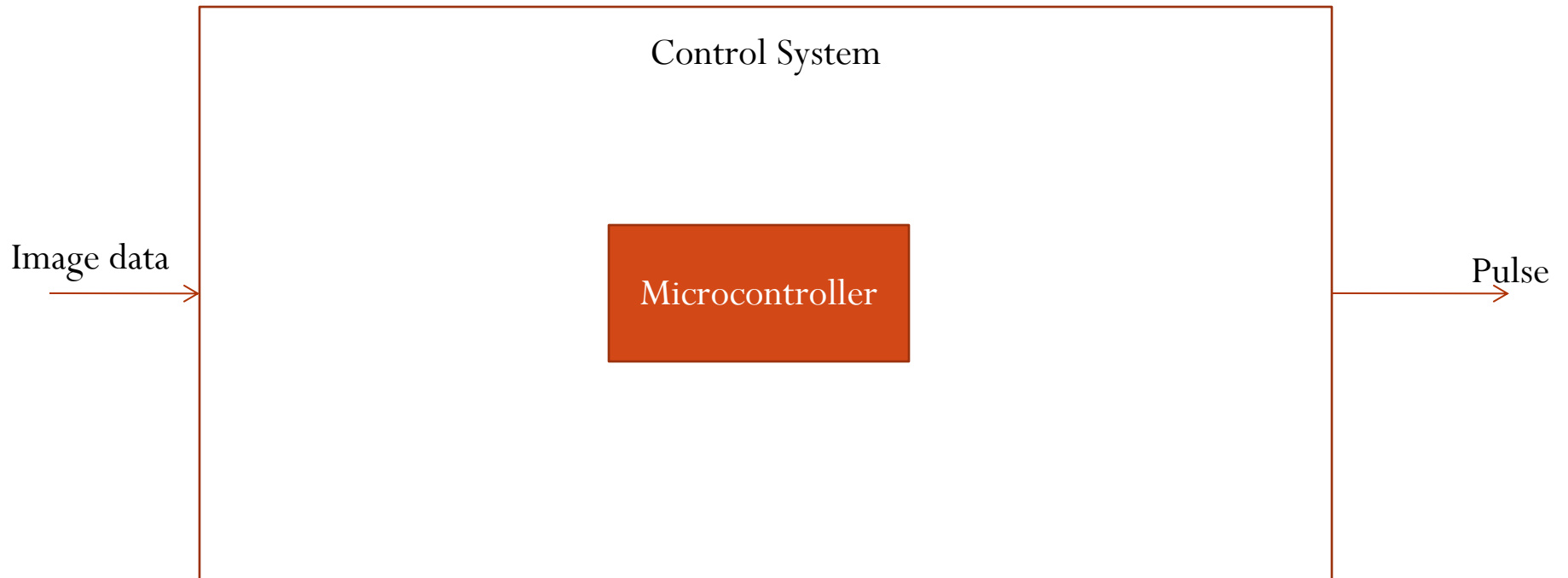
Drive System (Mechanical)



Scanning Head (Electronic and Electrical)



Control System



Components of Mechatronics Systems

- Mechanical System
- Electrical System
- Information System

Mechanical Systems and Analysis

Types of Systems

- Rigid – Rigid Multibody Simulation
- Deformable – Failure analysis, Finite Element Method (FEM)
- Fluid – Computational Fluid Dynamics (CFD)

Some mechanical components used

- Rigid - Gears, drives, cams, bearings, etc.
- Flexible – Electroactive polymers, Shape memory alloys, fiber reinforced material
- Fluid - Hydraulic cylinder, pneumatic cylinder, etc.

Electrical Systems

- Motors and generators
- Sensors and actuators
- Solid state devices
- Circuits – signal conditioning, amplifiers, etc.
- Contact devices – relays, switches. Circuit breakers, fuses, etc.

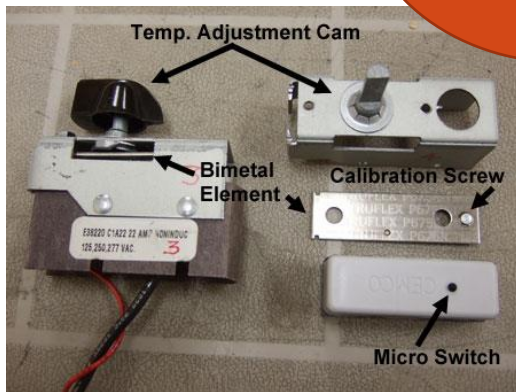
Information System

Information System consist of four parts

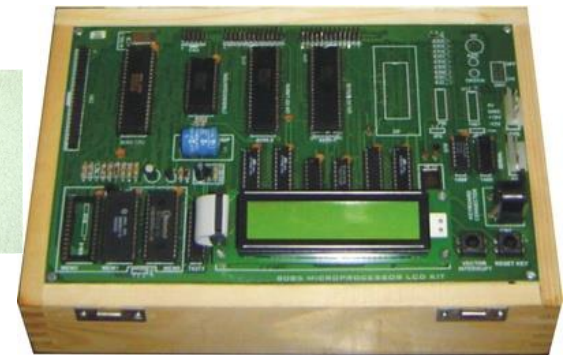
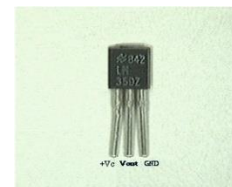
- Communication Systems
- Signal Processing
- Control System
- Numerical Solvers for Optimization
- Under Information System following activities are performed
 - Modeling
 - Simulation
 - Automatic Control
 - Optimization

Traditional Vs Mechatronics Based Design

- In traditional design individual subsystems were designed sequentially
 - Mech
 - Af
 - In modern design systems are currently as there are
- Concurrent design in mechatronics
 - More compact and easily reprogrammable
 - Electronics and mechanical parts complement each other
 - Most design and error checking completed using Simulation



Traditional bimetall strip based design



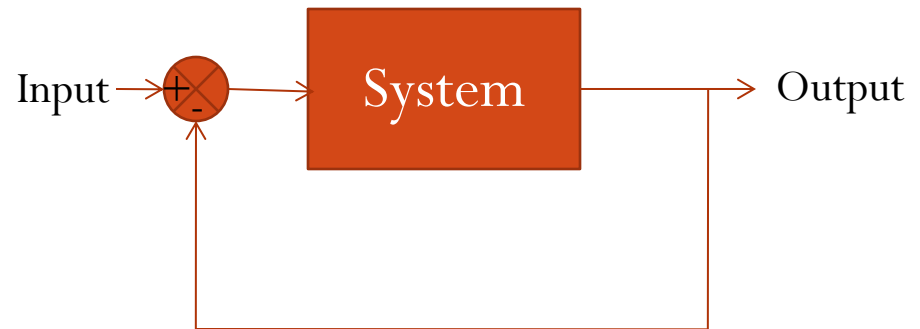
Closed-Loop and Open Loop Systems

- Open loop system look only it its input to determine what it should do



Open loop system

- Closed loop system looks both at its input as well as output to determine what to do



Feedback

Closed loop system

Examples

Open Loop System

- Control system of a microwave turns it off after set time
 - Does not look at temperature of food to “decide” turning off microwave
 - No feedback
- Regulator of Ceiling Fan depends on electrical resistance in the circuit
 - No feedback RPM is received by the regulator

Closed Loop System

- Temperature control system looks at the sensor readings of surrounding temperature
 - If different than desired temperature takes action

Summary

- *System* is an abstraction represented using box or block diagram which has an input and corresponding output/s
- Mechatronics system has following subsystems
 - Electrical System
 - Mechanical System
 - Information System
- Traditional design is sequential while mechatronics based design is concurrent

Next Class

- Electronics and electrical engineering fundamentals

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Homework 1

- Identify a mechatronics system in Mechanical Engineering Workshop/Labs.
 - Discuss why it is mechatronics based
 - Make a system diagram and break it down to as many subsystems as you can
 - Identify sensors and actuators and determine its technical specifications
- Use internet, lab manuals, and reference books to find information about components
- Date of submission August 10th, 2017 (during class)