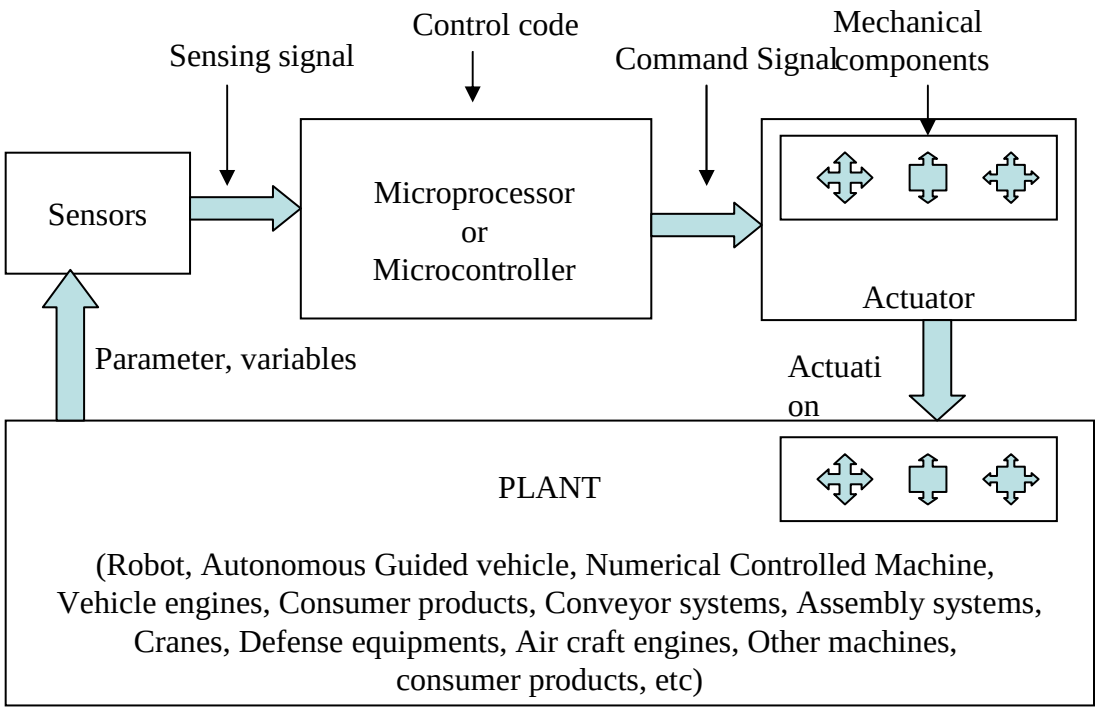
Introduction to Mechatronics

EEE436

Definition of Mechatronics

Mechatronics basically refers to mechanical electronic systems and normally described as a synergistic combination of mechanics, electrical, electronics, computer and control which, when combined, make possible the generation of simple, more economic, and reliable systems.

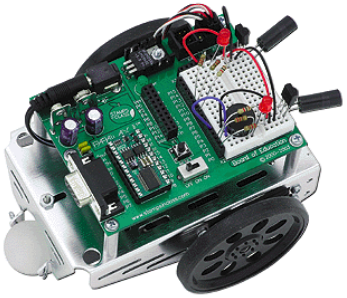
The term "mechatronics" was first assigned by Mr. Tetsuro Mori, a senior engineer of the Japanese company Yaskawa, in 1969.

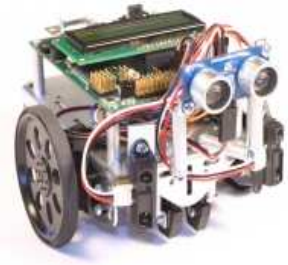


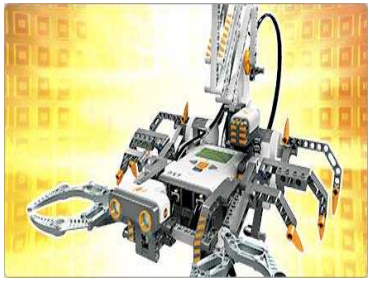
Physically, a mechatronic system is composed of four prime components. They are sensors, actuators, controllers and mechanical components. Figure shows a schematic diagram of a mechatronic system integrated with all the above components.

Example 1 of Mechatronic Systems

Robot





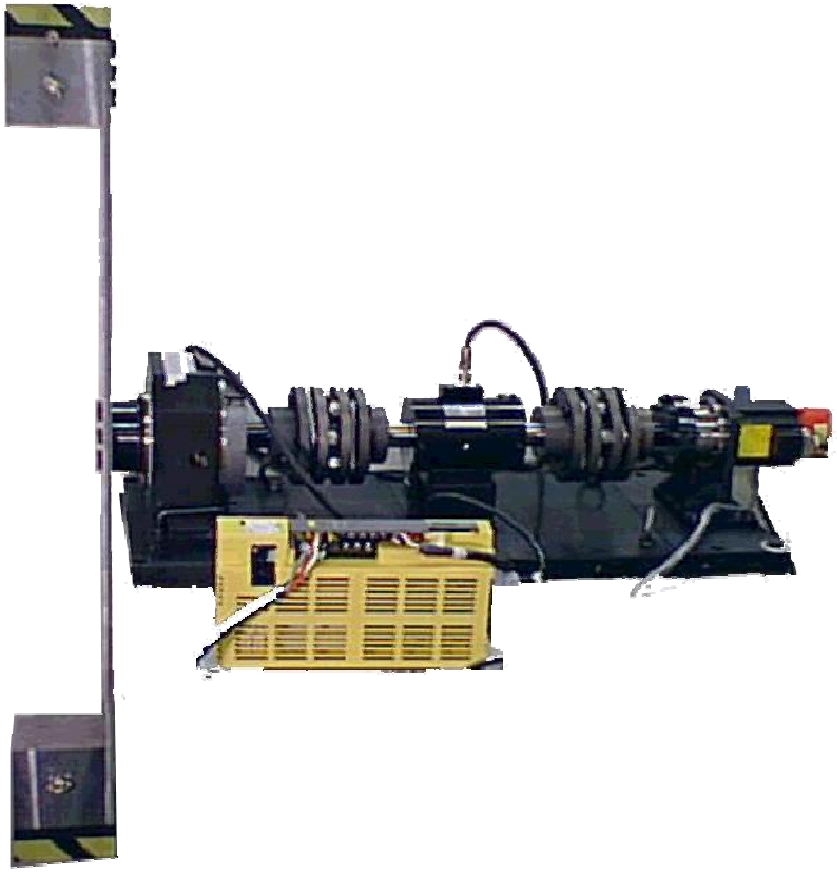


Robot examples

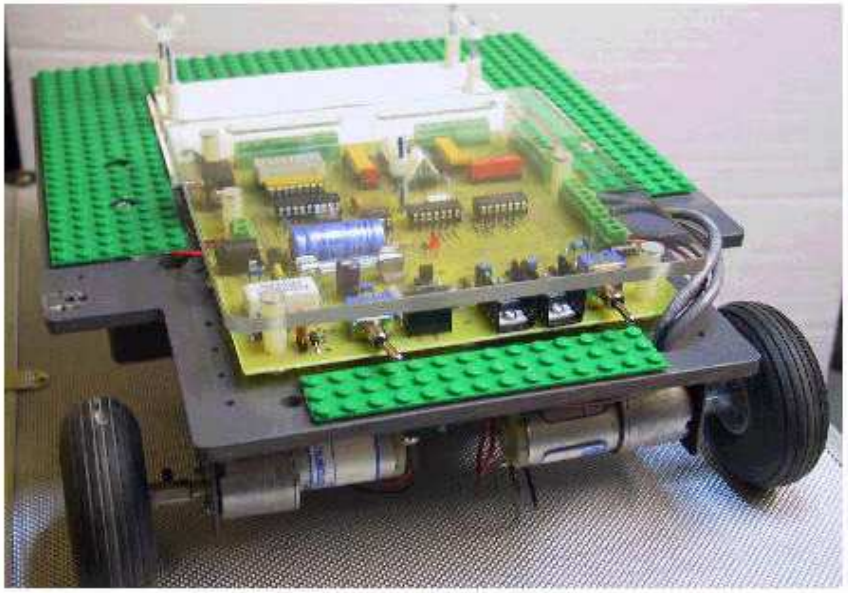
Robot sensors

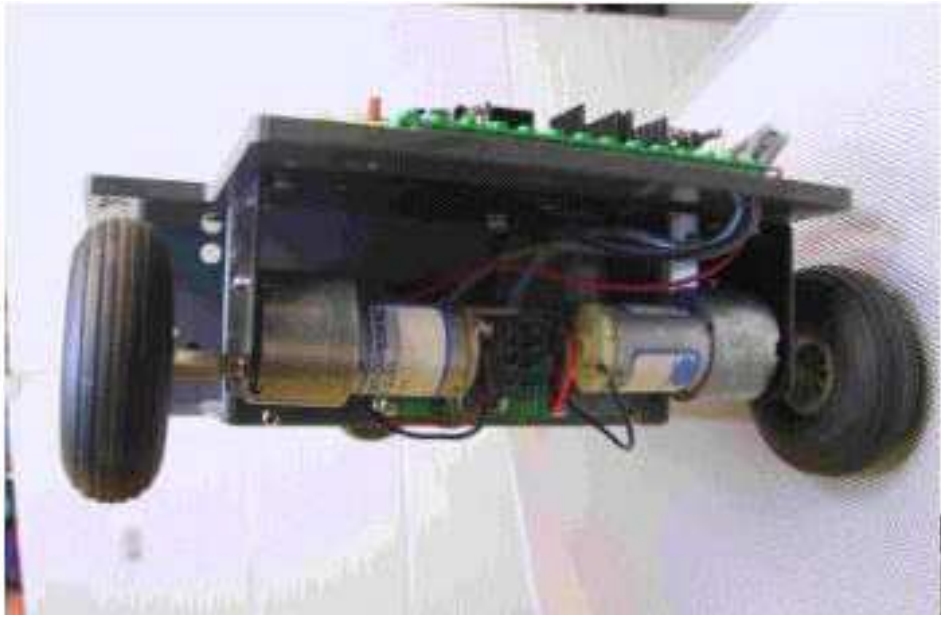
Example2 of Mechatronic Systems

Motion and Force Control of an Indirect Drive Robot



Examples: 3 of Mechatronic Systems





program to track straight line
• program for collision avoidance in outside corridor

Example: 4 of Mechatronic Systems

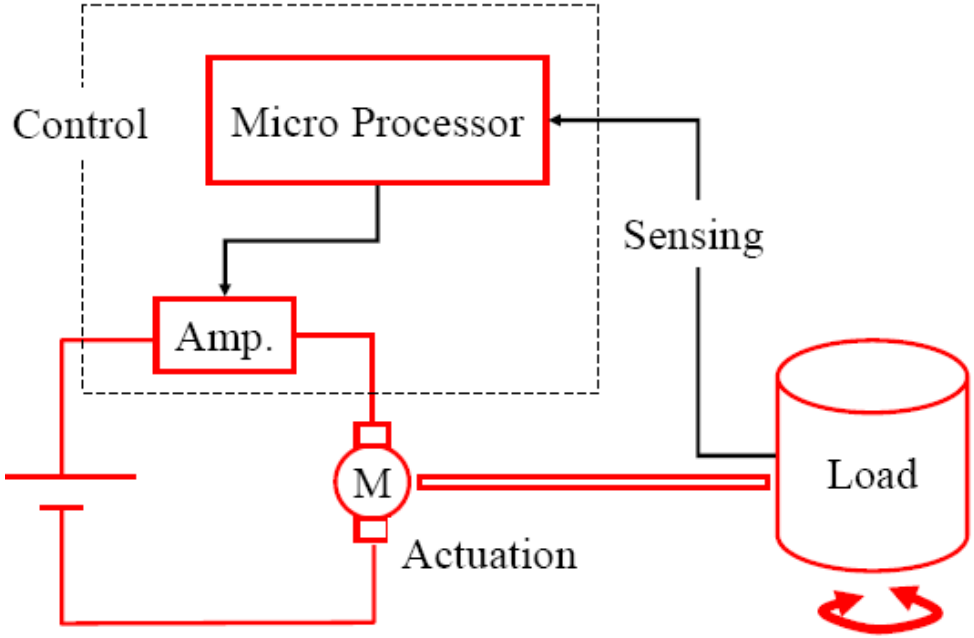
A computer disk drive is an example of a rotary mechatronic system

- Requires
  - Accurate positioning of the magnetic read head
  - Precise control of media speed
  - Extraction of digital data from magnetic media

Example: 5 of Mechatronic Systems

Washing Machine

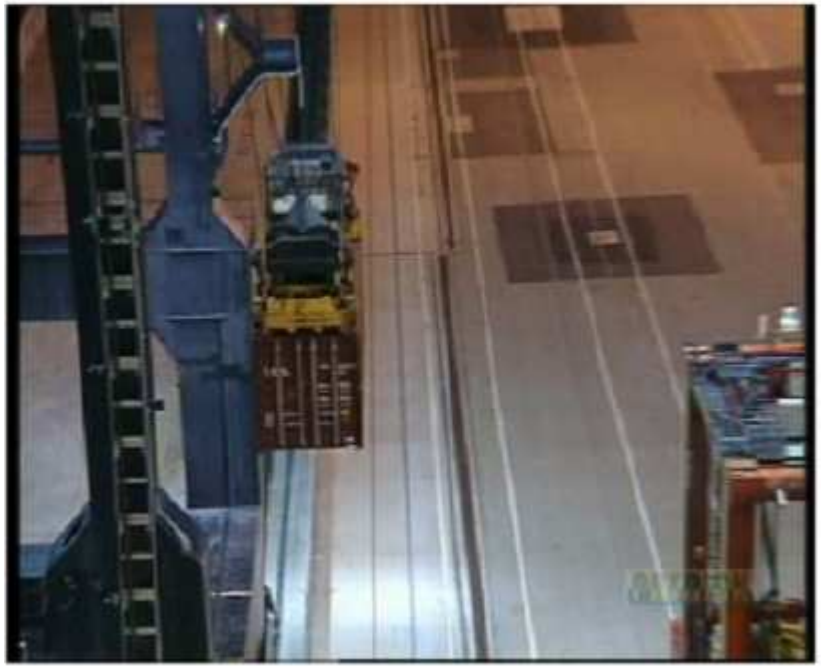
- System Requirements
  - Understanding of load sizes
  - Receptacle to hold clothes
  - 'Plumbing' (depth measurement)
  - Agitation of drum
  - Ease of use, Reliability
  - Low Cost
- Actuators
  - AC or DC Motors
  - Water inlet/drain
- Sensors
  - Water level
  - Load speed/balance



Example: 6 of Mechatronic Systems

Mechatronic is every where

Cargo Handling



- Automated Straddle Carriers
- Automated Crane Systems
- Automated movement vehicles

Example: 7 of Mechatronic Systems

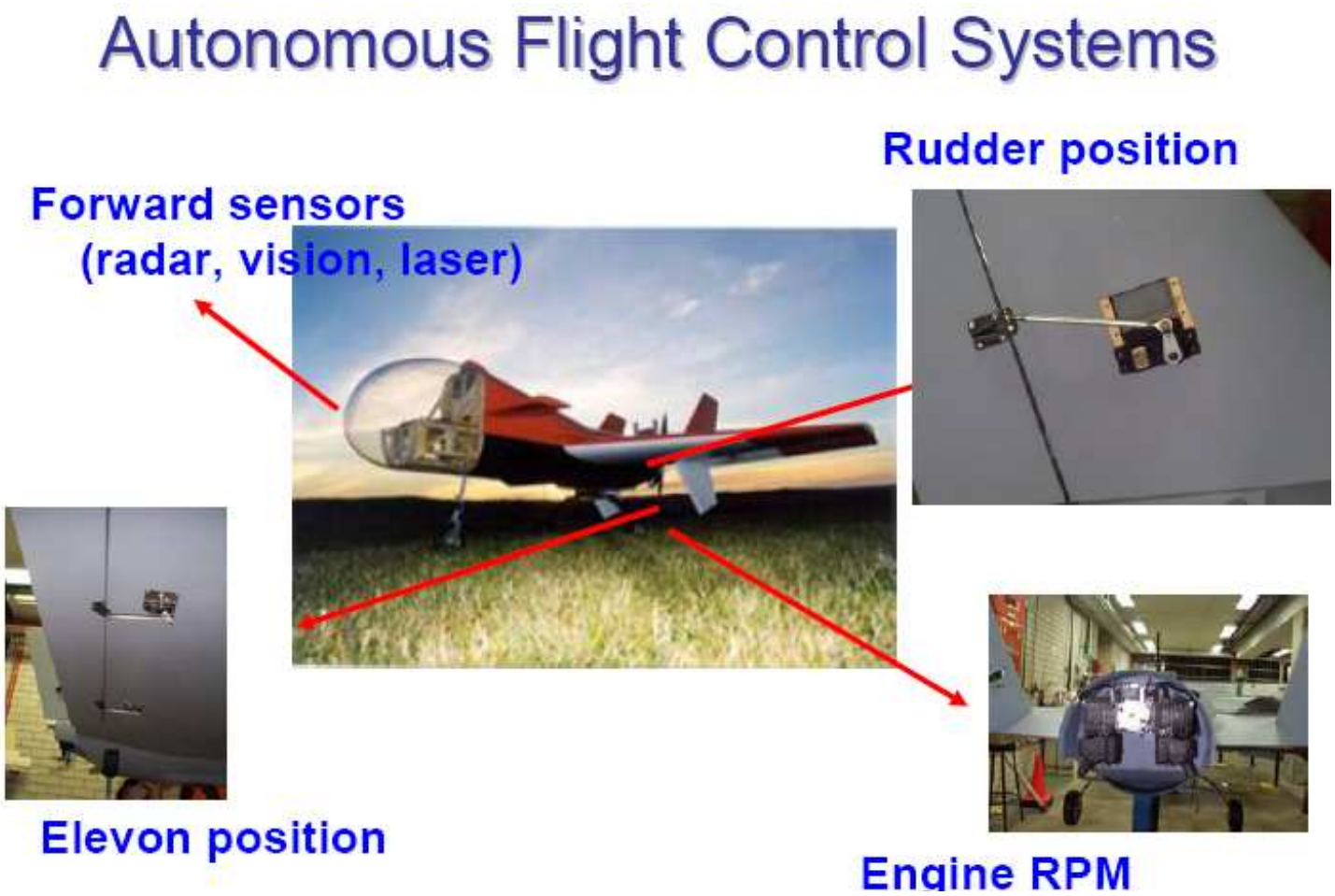
Mechatronic is every where

Subsea Vehicles

- Control of vehicle performed using on-board computer
- Sensors include sonar, vision, inertial, compass and pressure
- Used for building models of underlying reef structure

Example: 8 of Mechatronic Systems

Mechatronic is every where



Example: 9 of Mechatronic Systems

Mechatronic is every where

Units to be Covered

- **1** Introduction to mechatronic systems.
- **2** Sensors & Signal Conditioning.
- **3** Actuating Systems: Pneumatic and Hydraulic
- **4** Actuating Systems: Mechanical, Electrical ;
- **5** System Modeling: Mathematical Modeling, Electrical modeling
- **6** System Modeling: Mechanical Modeling, Thermal Modeling.
- **7** System Response.
- 8 Closed Loop Control.
- 9 Microprocessors and Microcontroller systems.
- 10 PLC system.
- **11** Mechatronic System Projects: Study case

Our approach to cover essential units

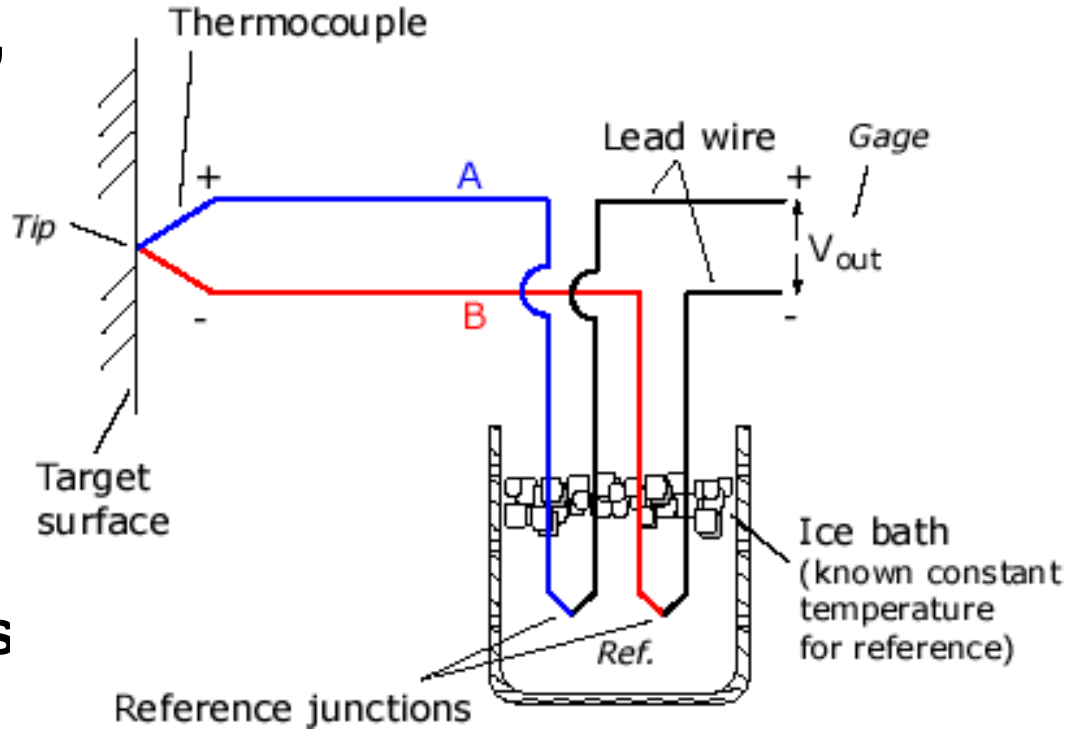
- Lectures,
- Exercises,
- Assignments ,
- Projects and presentation

Assessment Methods:

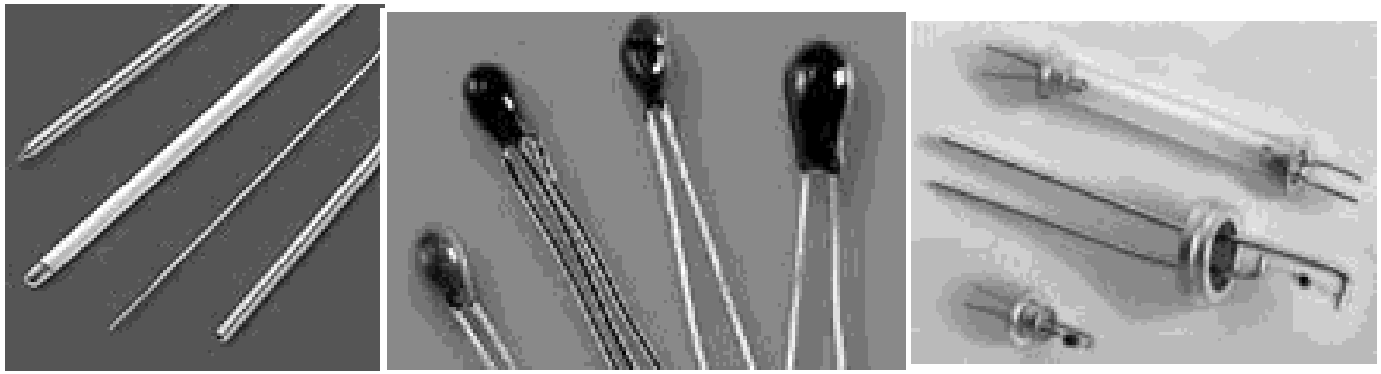
Method	Quantity	(%)
Project	1	20
Midterm Exam(s)	2	40
Final Exam	1	40

Sensors and Signal Conditioning

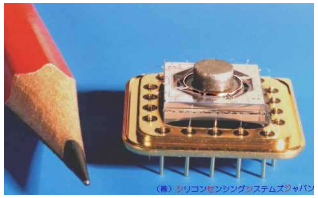
- **Sensors performance: Range, span, accuracy, sensitivity, errors,.. Resolution**
- **Displacement, position, motion and velocity sensors,**
- **Fluid sensors, liquid flow, liquid level**
- **Temperature sensors**
- **Light sensors**



Thermistors



A collection of Sensors


Gyroscope


Lever Switch


Linear Encoder


GPS


Camera


Laser Rangefinder


Piezo Bend


Accelerometer


Sonar Ranging


PIR


Rotary Encoder

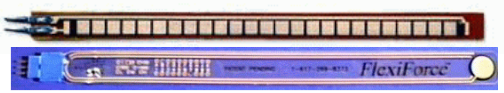

Metal Detector


Pendulum Resistive Tilt


Gas


Pyroelectric Detector


Pressure



Resistive Bend

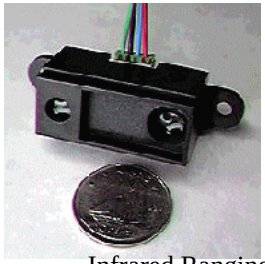

UV Detector

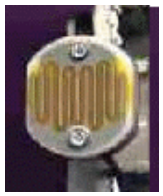

Radiation


Magnetometer


IR Modulator Receiver


Microphone

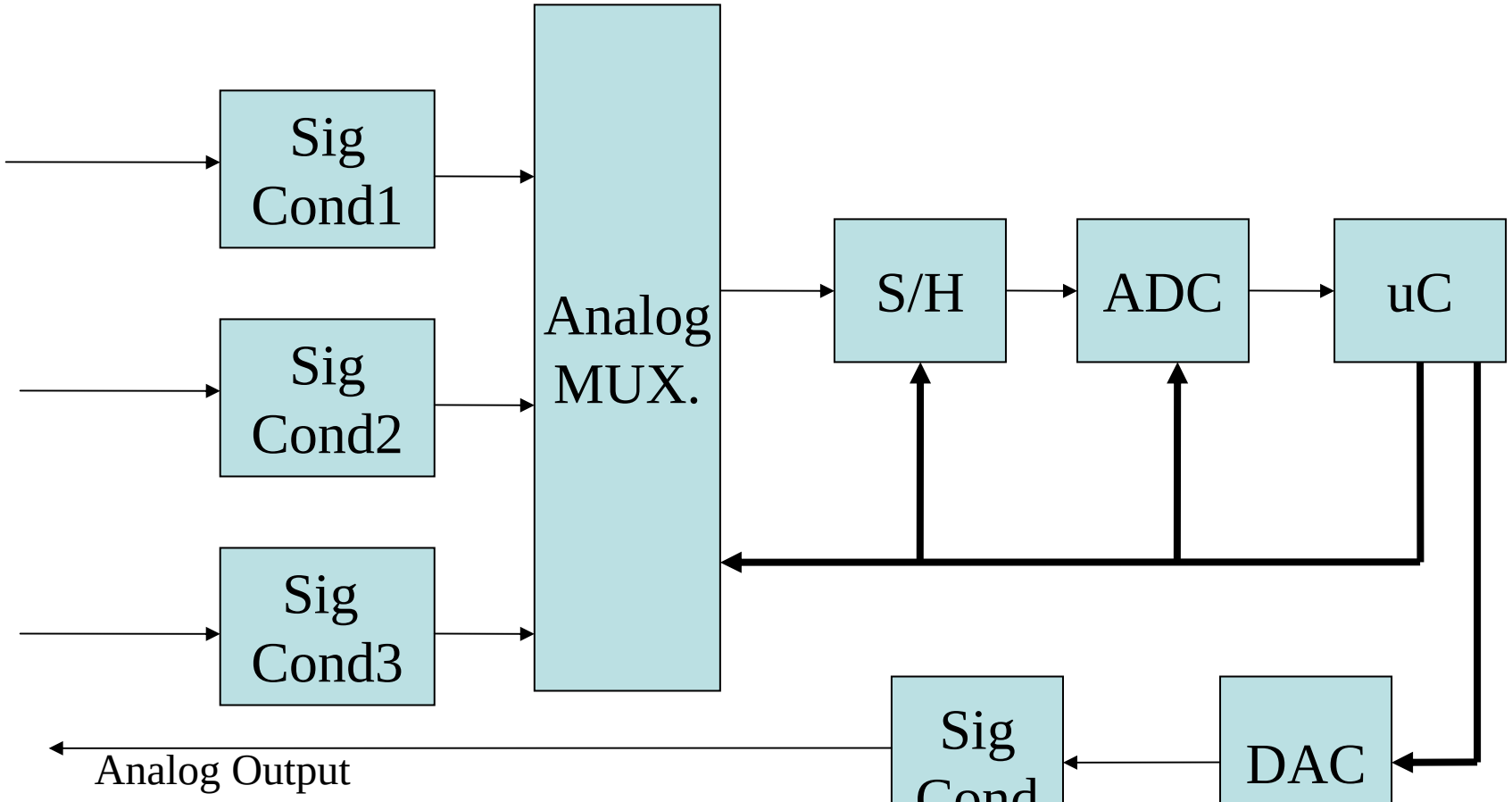

Infrared Ranging


CDS Cell

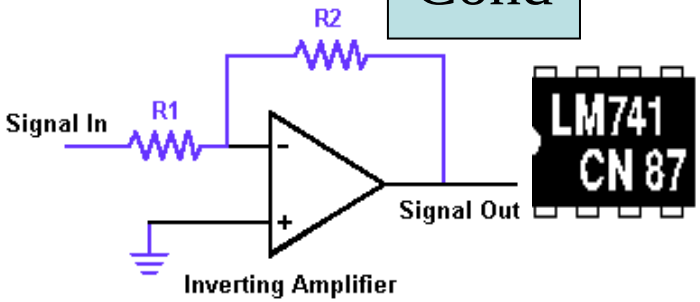

Compass

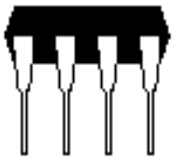

Magnetic Reed Switch

Signal conditioning circuits



- Opamps circuit
- ADC/DAC circuits
- Wheatstone bridge

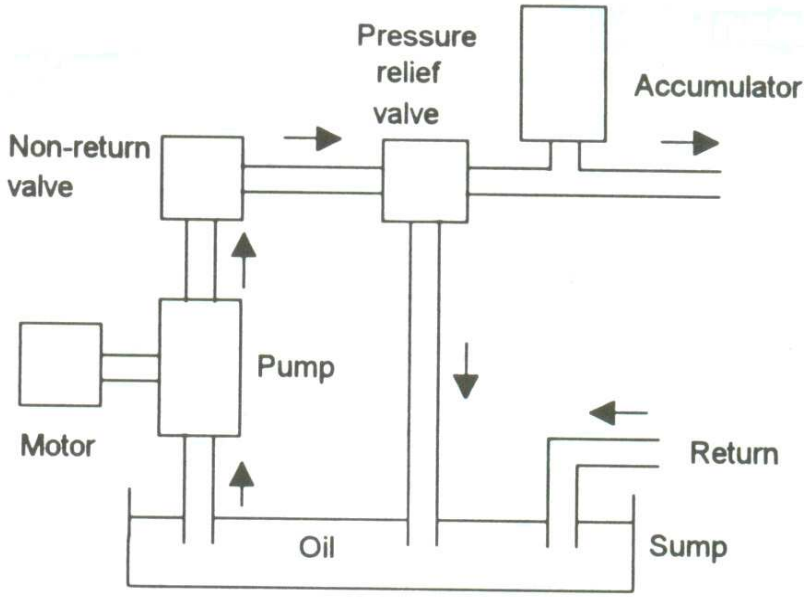


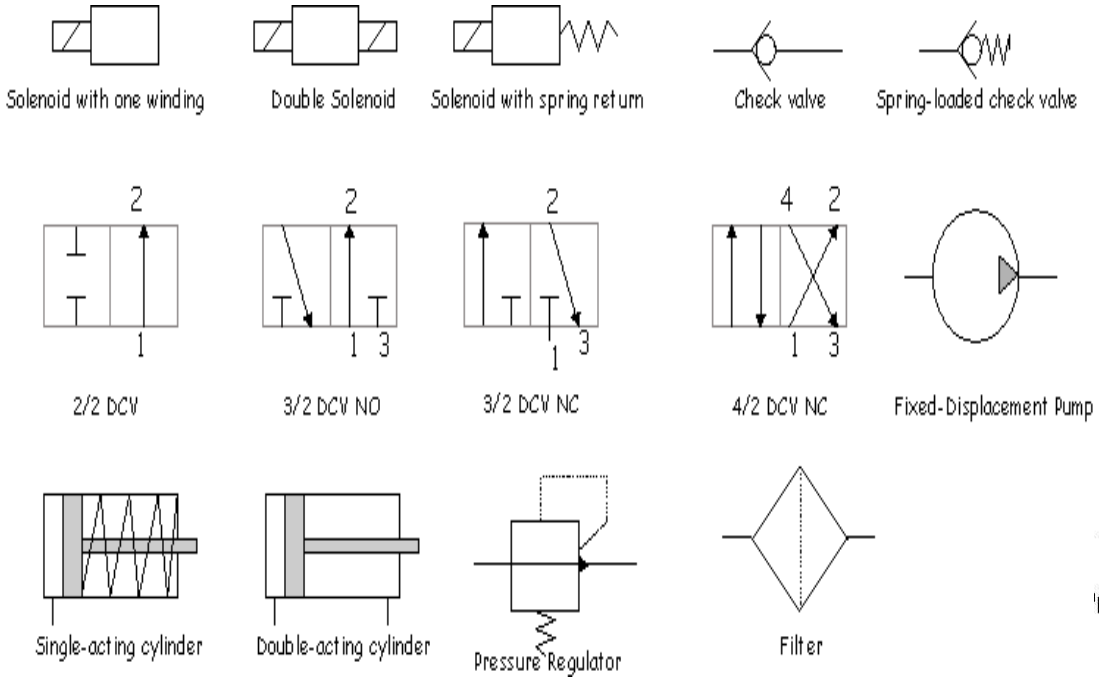


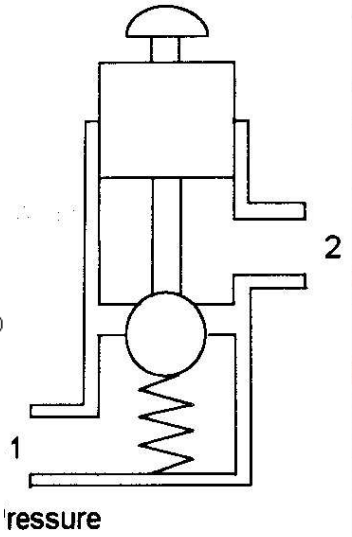
Actuating System: Pneumatic and Hydraulic

Hydraulic Power Supply

- Pump
- Check valve
- Accumulator
- Pressure relief valve
- Directional control valve
- Pressure control valve
- Process control valve







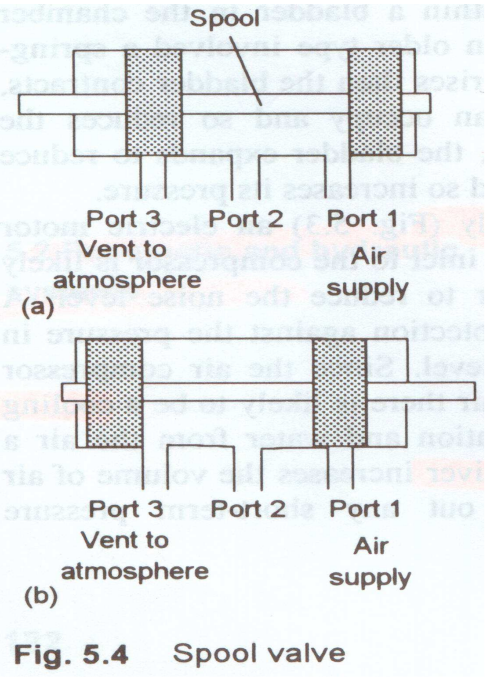


Fig. 5.4 Spool valve

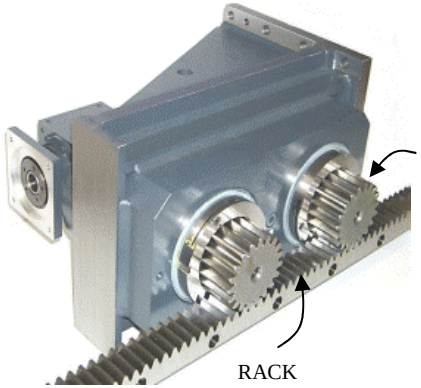
Actuating System: Mechanical

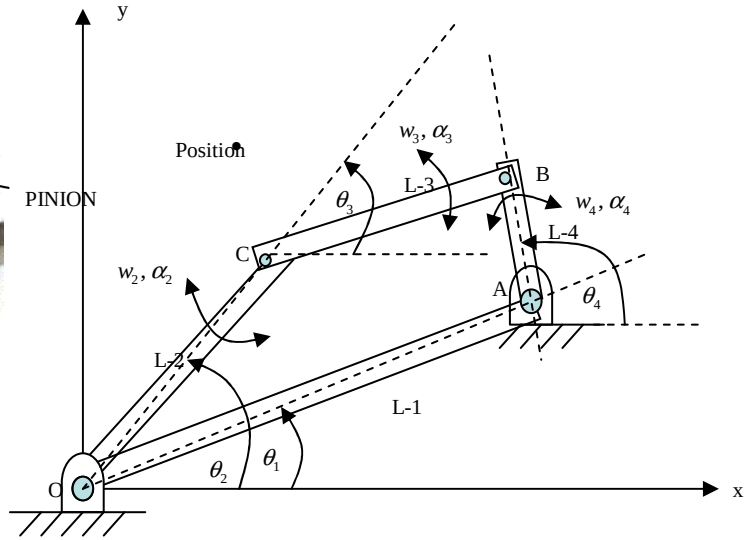
- Types of motion
  - Freedom

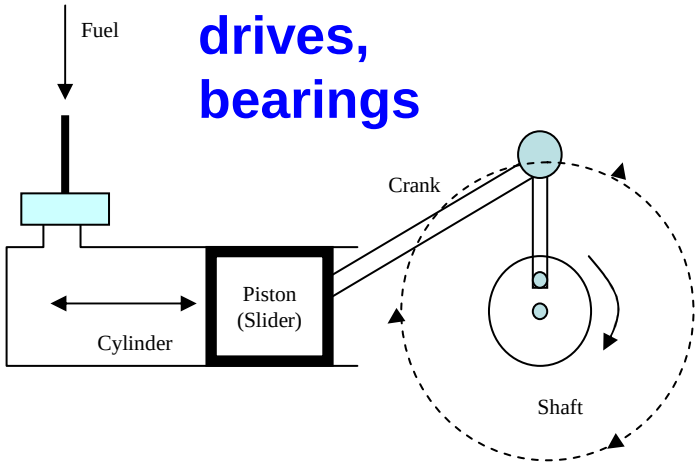
  Kinematic chains, bar chain links, slider-crank mechanism

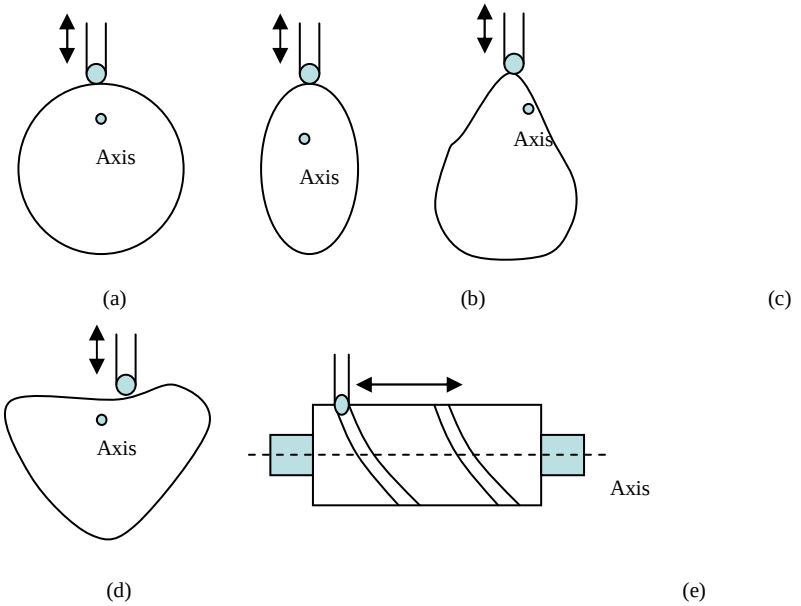
  Cams, gear trains

  Belt and chain drives, bearings









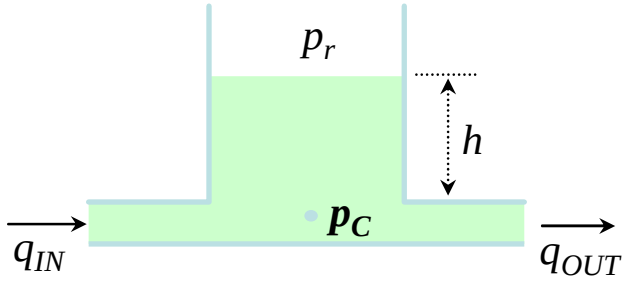
Electrical Actuation

- Switching devices
  - Mechanical switches
    - Keyboards, limit switches, switches
  - Relays
  - Solid-state switches
    - Diodes, thyristors, transistors
  - On-Off
- Solenoids
  - Push something
    - Starter solenoid, pneumatic or hydraulic valve
- Drive systems
  - DC., AC., or stepper motors
  - How to achieve speed control

System Modeling: Mathematical Modeling

- **Understand System Function and Identify Input/Output Variables**
- **Draw Simplified Schematics Using Basic Elements**
- **Develop Mathematical Model**

Ex: *Consider an open tank with a constant cross-sectional area, A:*



the rate of change in pressure, p,
the input flow rate, q_{IN} ,
the output flow rate, q_{OUT}

$$p_C = \rho g h + p_r = p_{Cr} = \rho g h$$

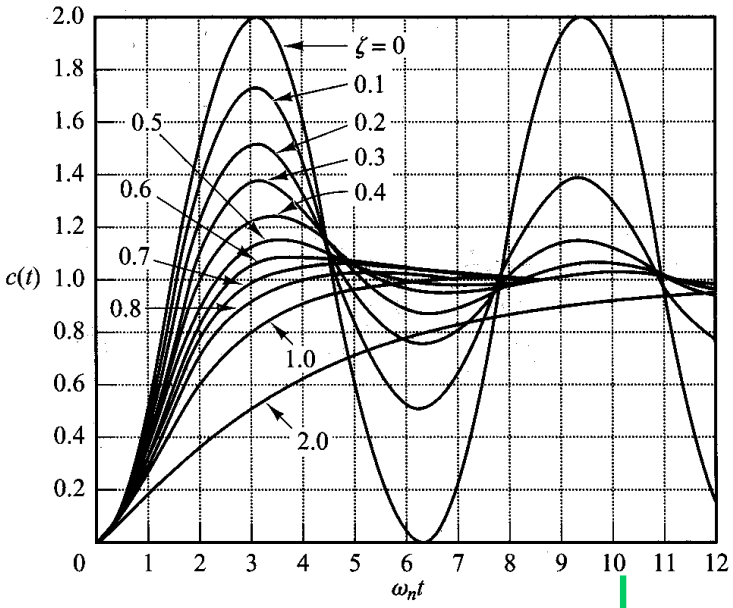
$$q_{IN} - q_{OUT} = \frac{d}{dt}(Volum) = \frac{d}{dt}(Ah) = A\dot{h}$$

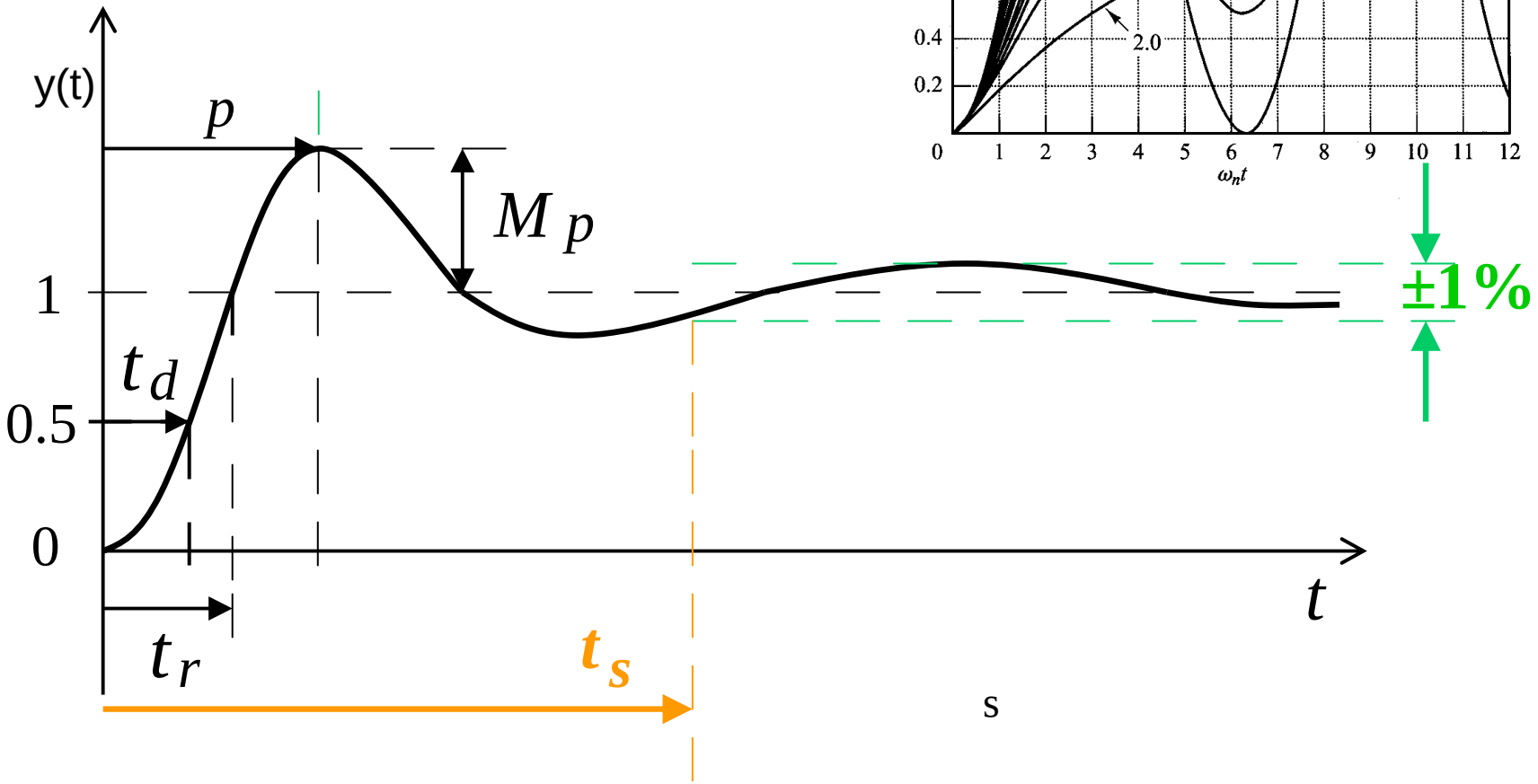
$$\dot{p}_{Cr} = \rho g \dot{h}$$

$$\Rightarrow C = \frac{q_{IN} - q_{OUT}}{\dot{p}_{Cr}} = \frac{A\dot{h}}{\rho g \dot{h}} = \frac{A}{\rho g}$$

System Response .

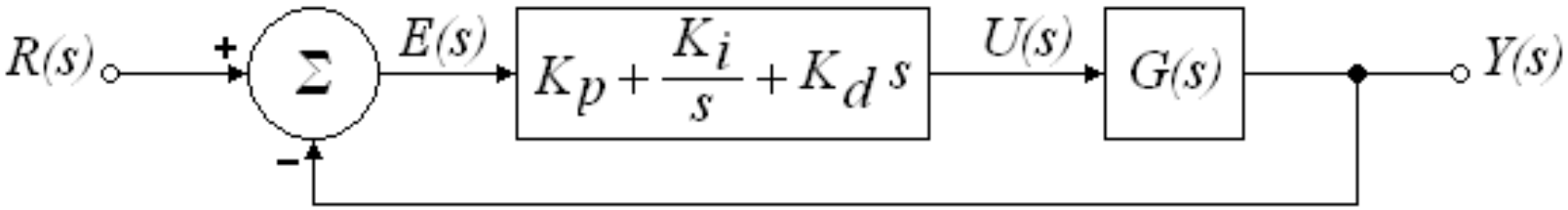
- Dynamic response
- Transient and steady state response
- First and second order system
- Frequency response system



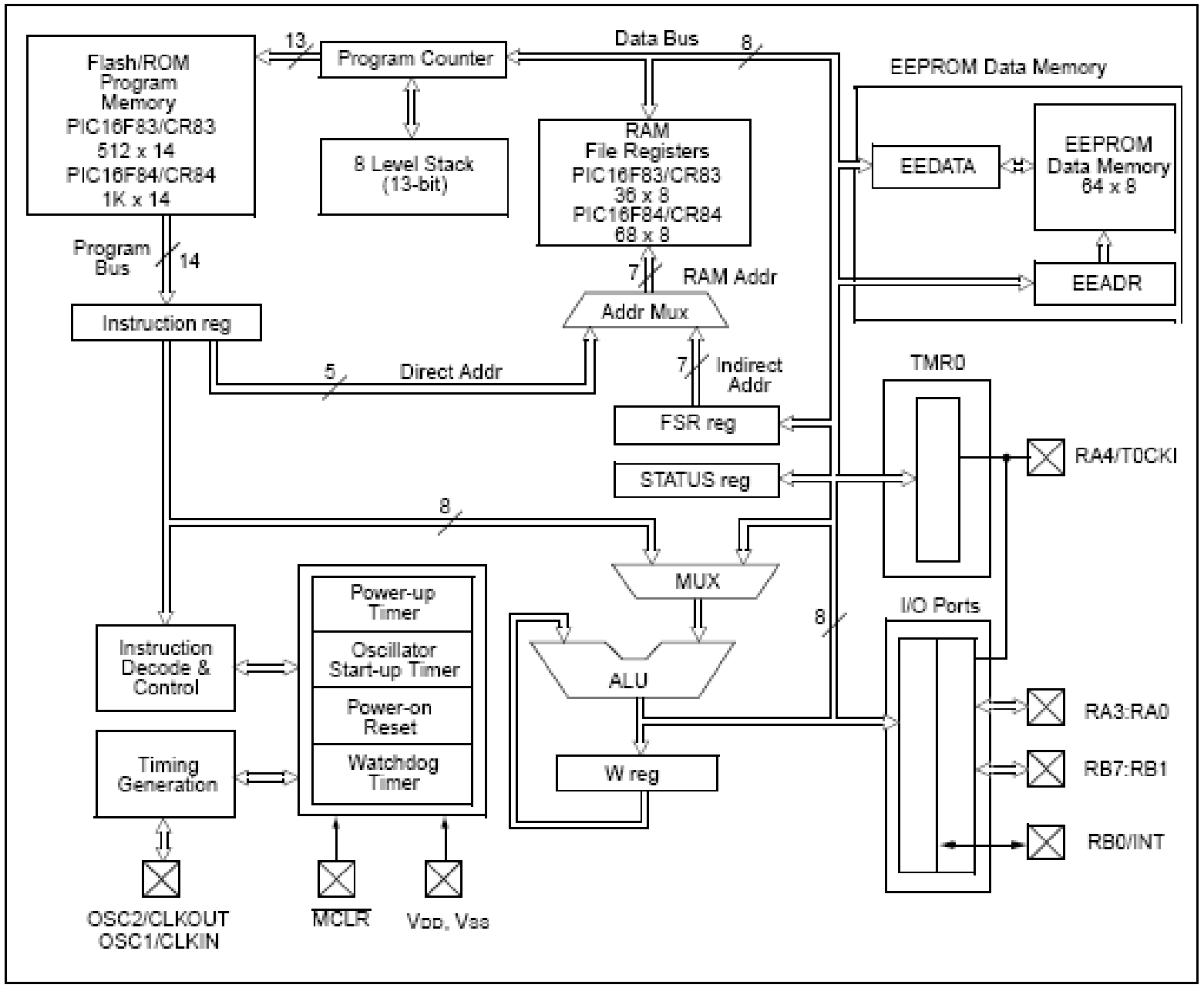


Closed Loop Control.

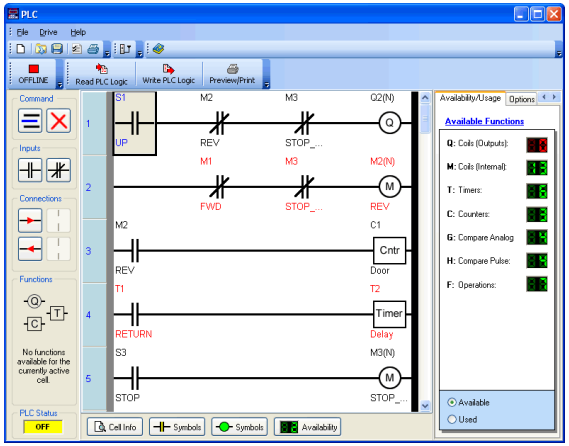
- Closed loop controls
- P, PI,PID controllers
- Digital Controllers
- Implementing control modes
- Adaptive control



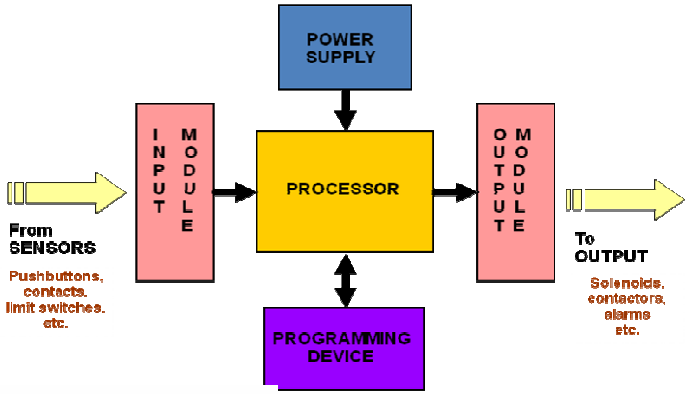
Microprocessors / Microcontroller systems

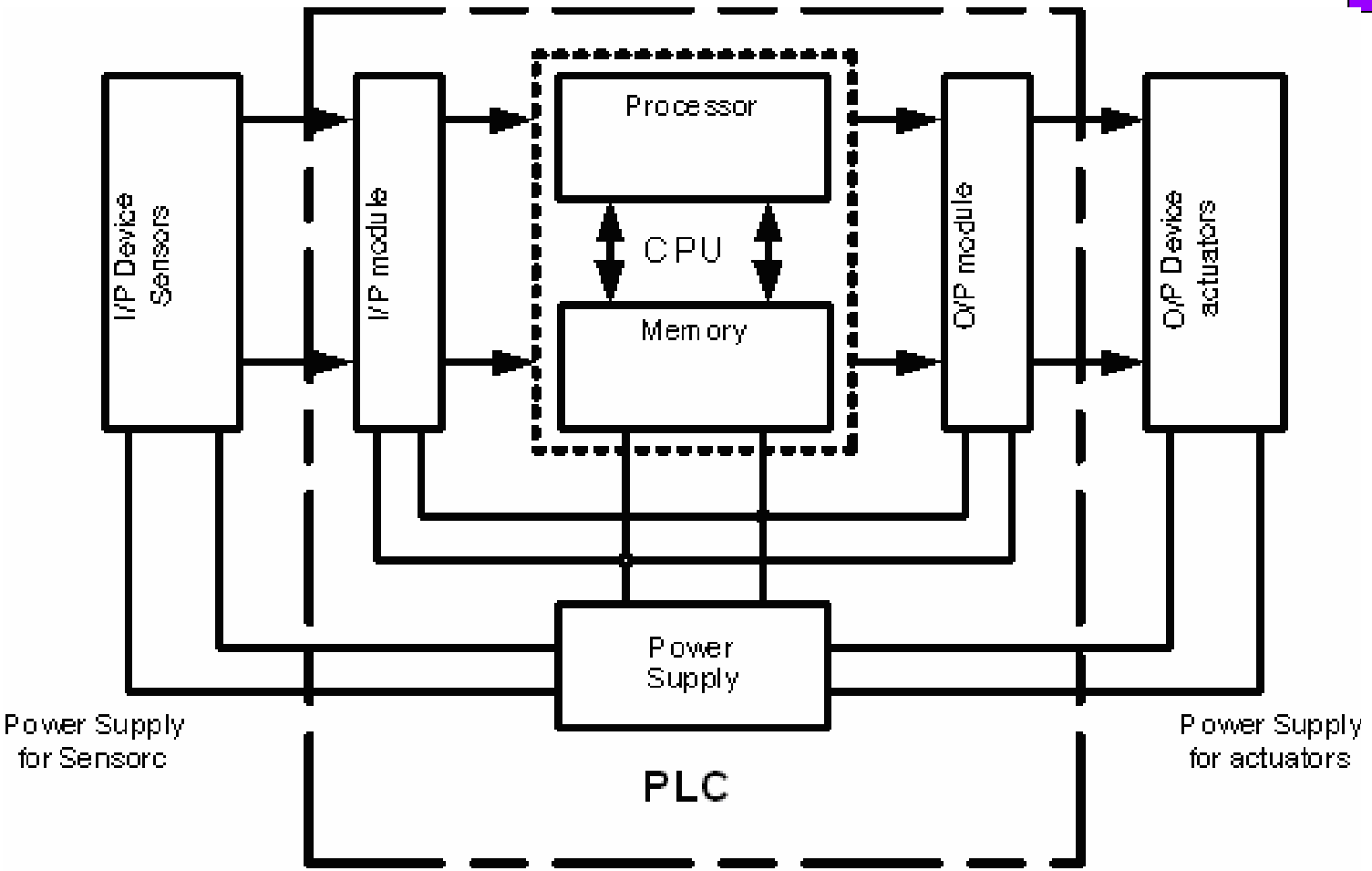


PLC System


PLC
File Drive Help
OFFLINE
Read PLC Logic
Write PLC Logic
Preview/Print
Command
Inputs
Connections
Functions
PLC Status
OFF
S1
UP
M2
REV
STOP_...
Q2(N)
Q
M1
FWD
M3
M2(N)
REV
C1
Cntr
Door
T1
RETURN
T2
Timer
Delay
S3
STOP
M3(N)
Availability/Usage
Options
Available Functions
Q: Coils (Outputs):
M: Coils (Internal):
T: Timers:
C: Counters:
G: Compare Analog:
H: Compare Pulse:
F: Operations:
Available
Used
Cell Info
Symbols
Symbols
Availability

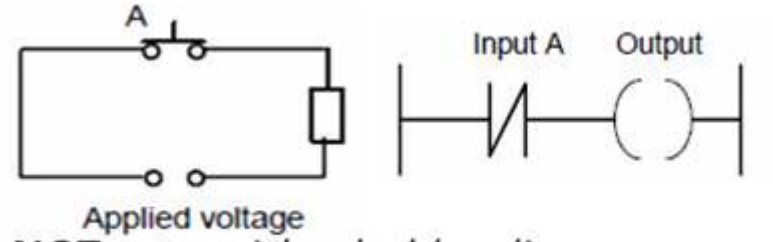
PLC system


Major Components of a Common PLC
POWER SUPPLY
INPUT MODULE
PROCESSOR
OUTPUT MODULE
PROGRAMMING DEVICE
From SENSORS
Pushbuttons, contacts, limit switches, etc.
To OUTPUT
Solenoids, contactors, alarms etc.

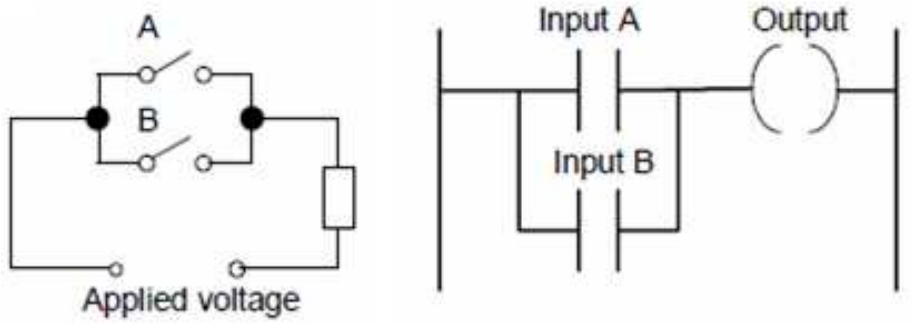

I/P Device Sensors
I/P module
Processor
CPU
Memory
O/P module
O/P Device actuators
Power Supply
Power Supply for Sensorc
Power Supply for actuators
PLC

PLC system

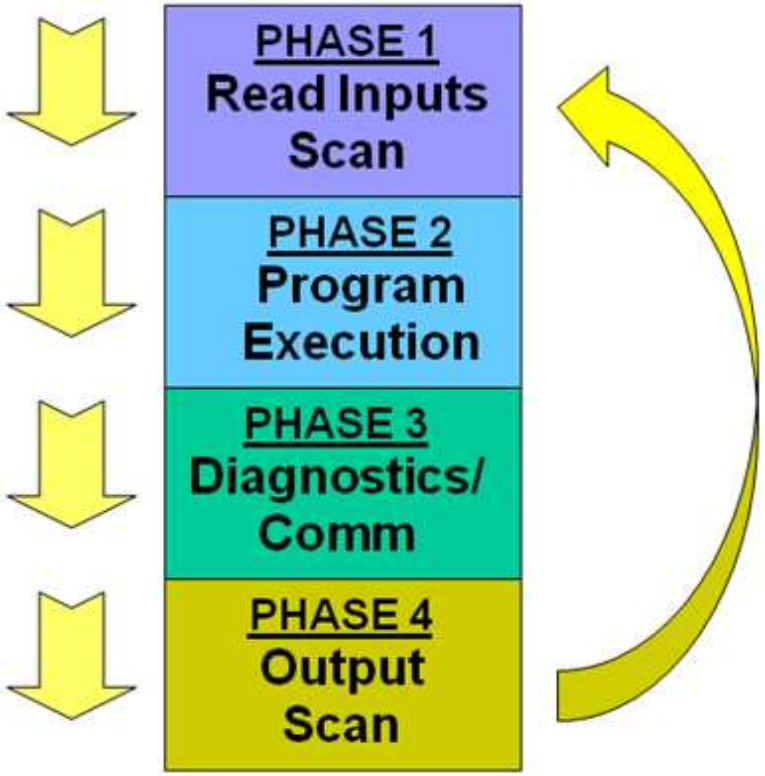
- PLC programming
- PLC Ladder and functional block

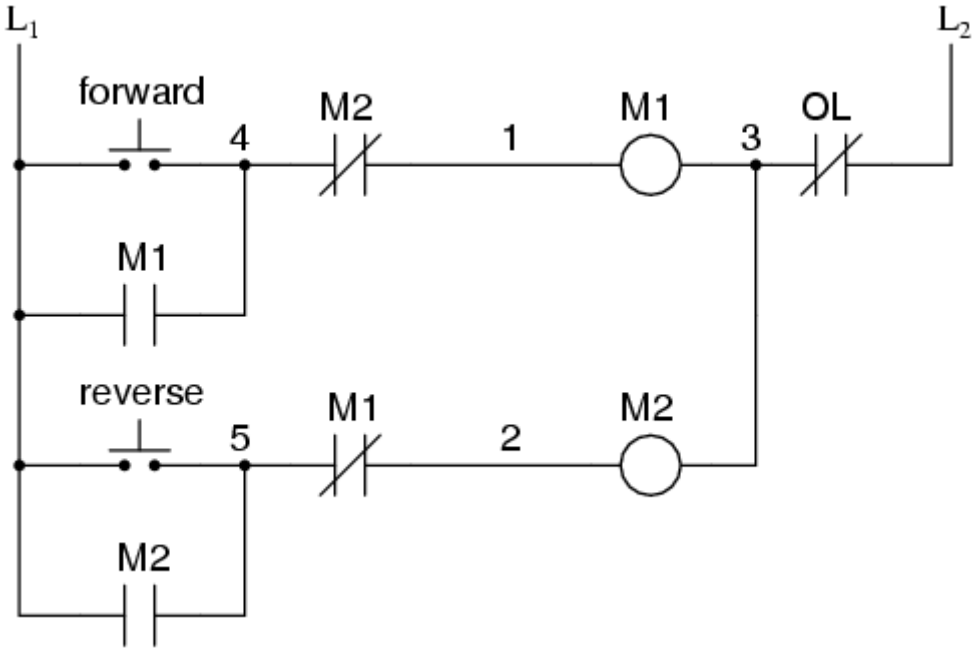


NOT gate with a ladder diagram rung

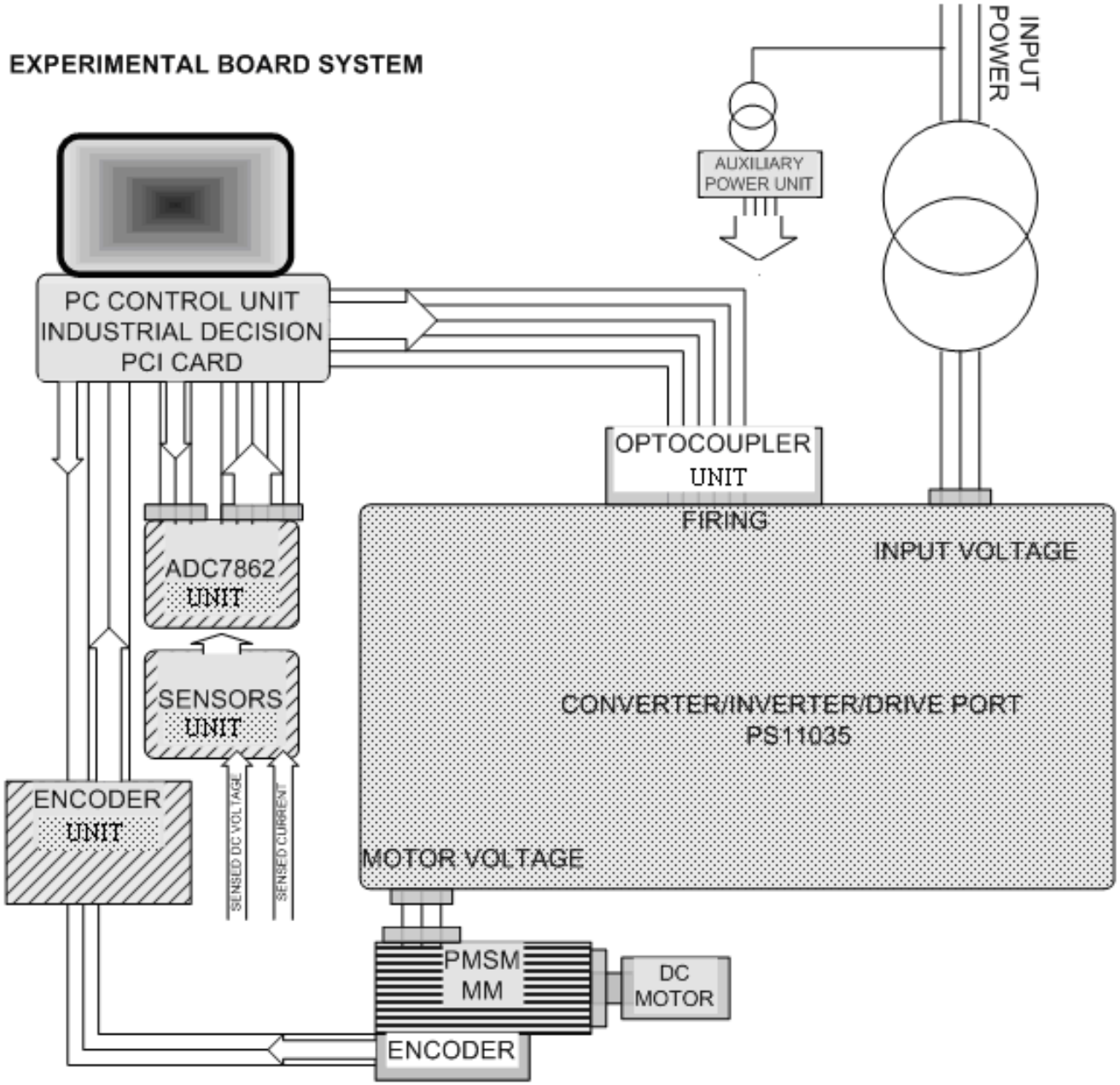


OR gate with a ladder diagram rung

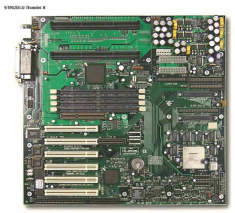




Case Study: Motor Control



PC-based Measurement and Control

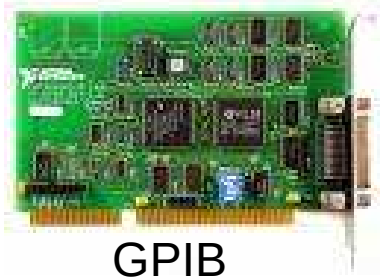


Pc Board

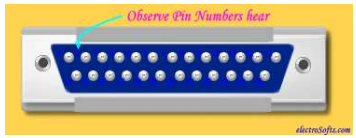
USB Symbol

http://www.computerhope.com

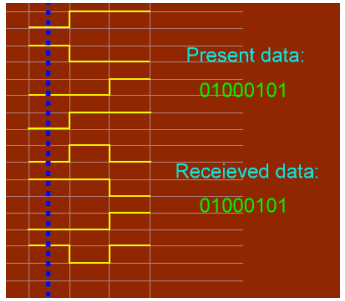
CAN BUS

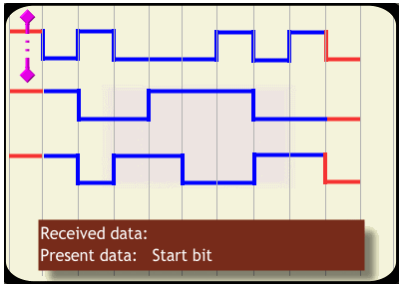


GPIB

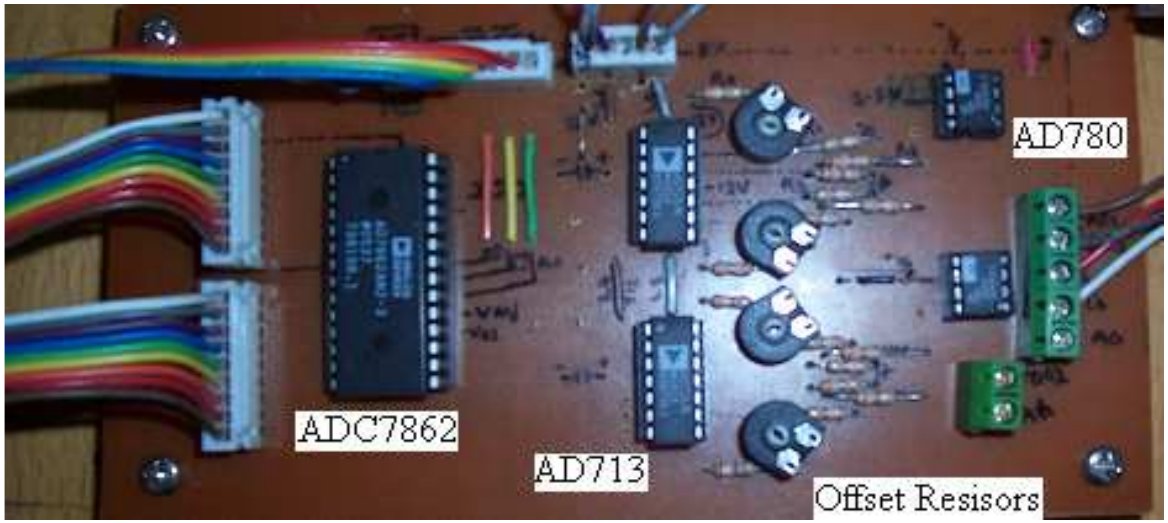


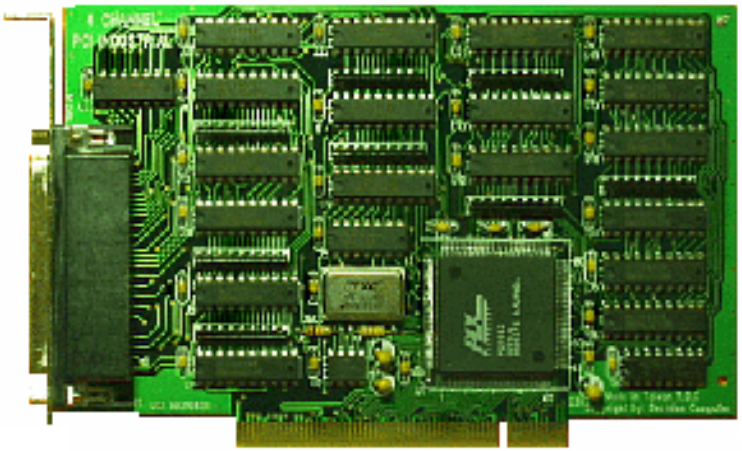
Serial/paralell



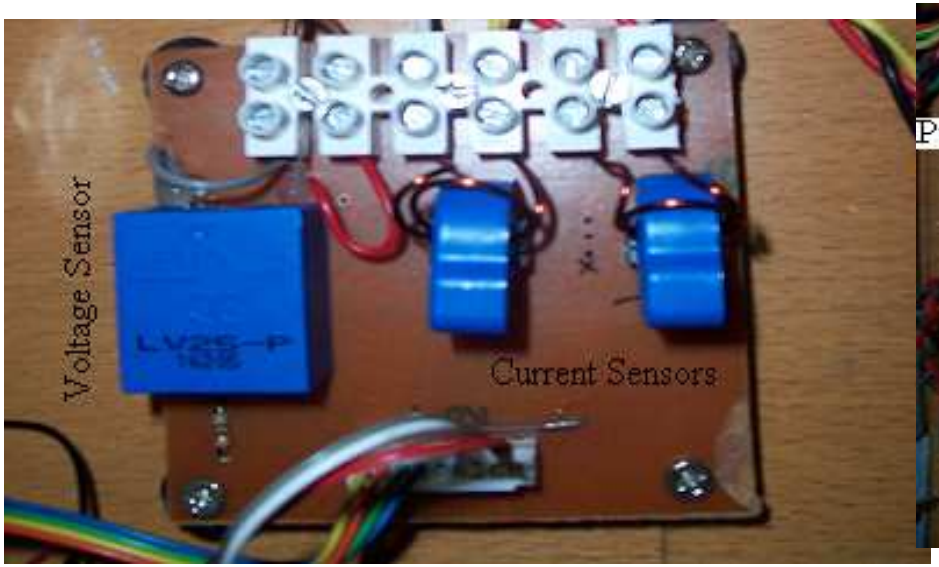


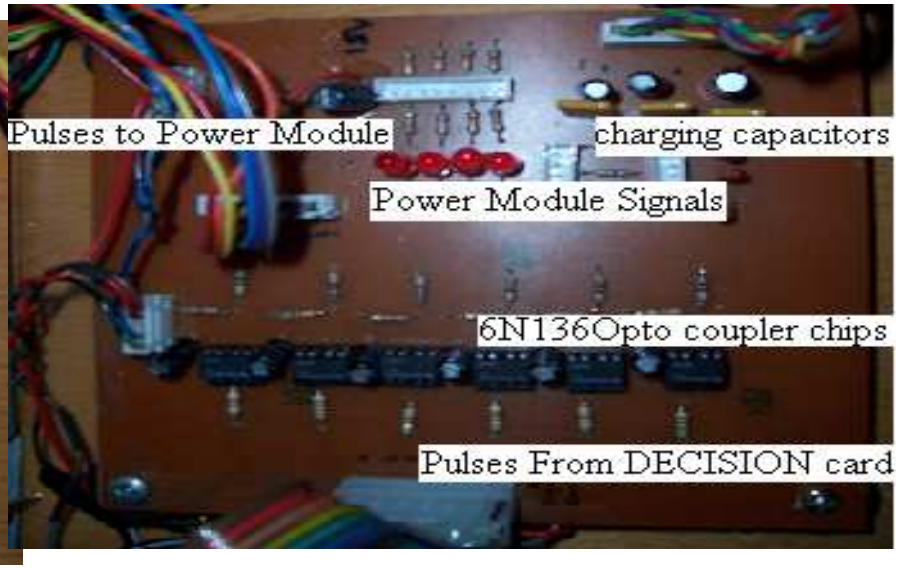
Case Study: Motor Control





PCI INDUSTRIAL CARD





Projects

- Select one of the Mechatronic components and write , present and submit your projects
- Examples:
- Sensors:
- Robot sensor
- Biomedical engineering sensors
- PIC, 8051
- PLC
- …….etc
- DC motor speed control
- Washing machine mechanism
- ...etc.....
- Starting of IM with PLC
- Temperature measurement and display with 8051