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NPTEL ONLINE CERTIFICATION COURSE

MECHATRONICS

INTRODUCTION

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MECHANICAL & INDUSTRIAL ENGINEEING, IIT ROORKEE

Introduction

- Introduction to mechatronics and mechatronics approach
- Measurement system
- Control systems
- Microprocessor based controllers

Sensors and Transducers

- Performance terminology
- Photoelectric transducers
- Flow transducers
- Optical sensors and transducers
- Semiconductor lasers
- Selection of sensors
- Mechanical/electrical switches, inputting data by switches

Actuators and Mechanisms

- Actuation systems
- Pneumatic and hydraulic systems
- Process control valves
- Rotary actuators
- Mechanical actuation systems
- Electrical actuation systems

Signal conditioning

- Signal conditioning
- Filtering digital signals
- Multiplexers
- Data acquisition
- Digital signal processing
- Pulse modulation
- Data presentation systems

Microprocessors and Microcontrollers:

- Control
- Microcomputer structure
- Microcontrollers applications
- Programmable logic controllers.

Modeling & System Response

- Mathematical models
- Mechanical
- Electrical
- Hydraulic
- Thermal Systems
- Dynamic response of systems
- Transfer function and frequency response
- Closed loop controllers
- MATLAB as development tool

Design and Mechatronics

- Input/output system
- Computer based modular design
- System validation
- Remote monitoring and control
- Designing
- Possible design solutions
- Case studies

Books

- W. Bolton, Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering (6th Edition), Pearson, 2015
- D.G. Alciatore and Michael B. Histand, Introduction to Mechatronics, Tata Mc Graw Hill, 2012.
- Shetty Dedas, Kolk and Richard, Mechatronic system Design; Cengage Learning, Inc; 2nd ed. Edition, 2010
- Bishop, Mechatronic handbook, CRC press, 2002.
- R. Merzouki, A. K. Samantaray, P. M. Pathak, B. Ould Bouamama, Intelligent Mechatronic Systems: Modeling, Control and Diagnosis, ISBN 978-1-4471-4627-8, 2013, Springer, London

Mechatronics Definition

- Yasakawa Electric Company, In trademark application documents, Yasakawa defined mechatronics as
  - The word, mechatronics, is composed of “mecha” from mechanism and the “tronics” from electronics.
- In other words, technologies and developed products will be incorporating electronics more and more into mechanisms, intimately and organically, and making it impossible to tell where one ends and the other begins.

- Harashima, Tomizuka, and Fukada in 1996
  - the synergistic (working together) integration of mechanical engineering, with electronics and intelligent computer control in the design and manufacturing of industrial products and processes.
- Auslander and Kempf, 1996
  - Mechatronics is the application of complex decision making to the operation of physical systems.

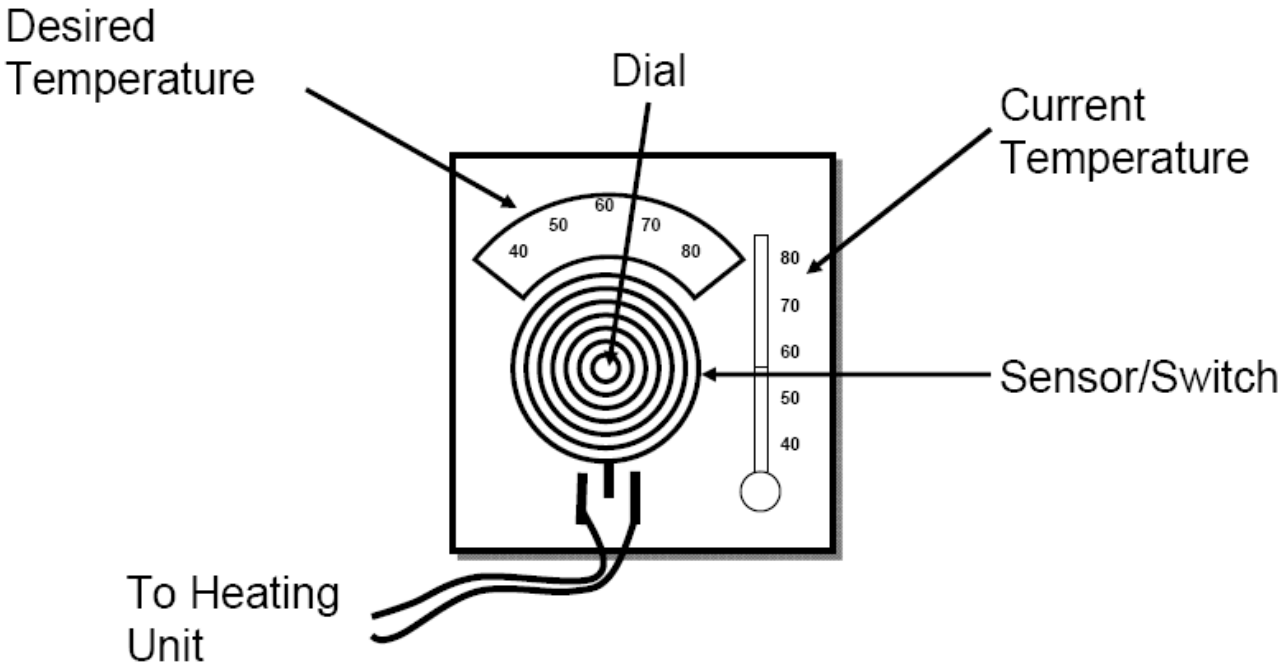
- Shetty and Kolk in 1997
  - Mechatronics is a methodology used for the optimal design of electromechanical products.
- W. Bolton
  - A mechatronic system is not just a marriage of electrical and mechanical systems and is more than just a control system; it is a complete integration of all of them.

- Mechatronics is generally
  - recognized worldwide as a vibrant area of study.
  - Undergraduate and graduate programs in mechatronic engineering are now offered in many universities.
  - Refereed journals are being published and dedicated conferences are being organized and are generally highly attended.

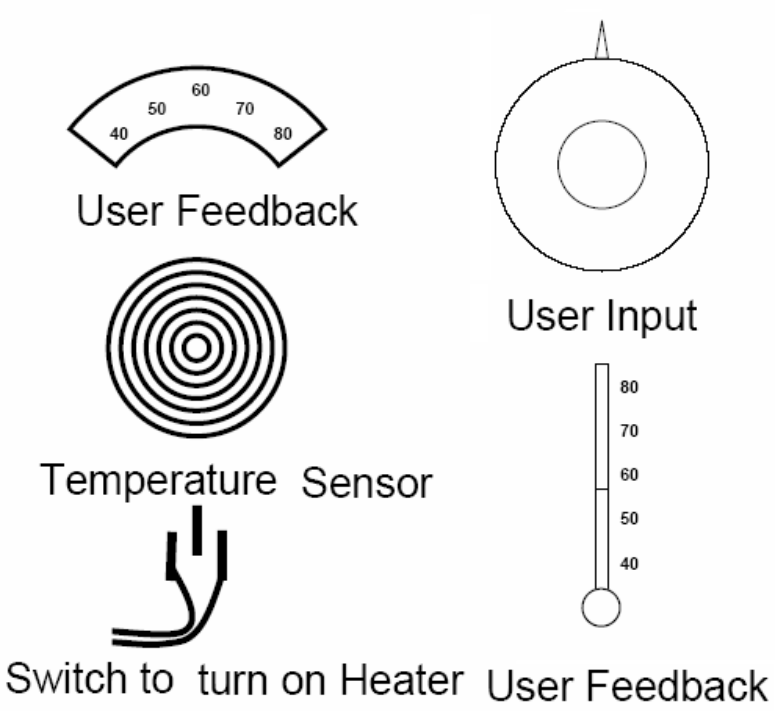
Mechatronics?

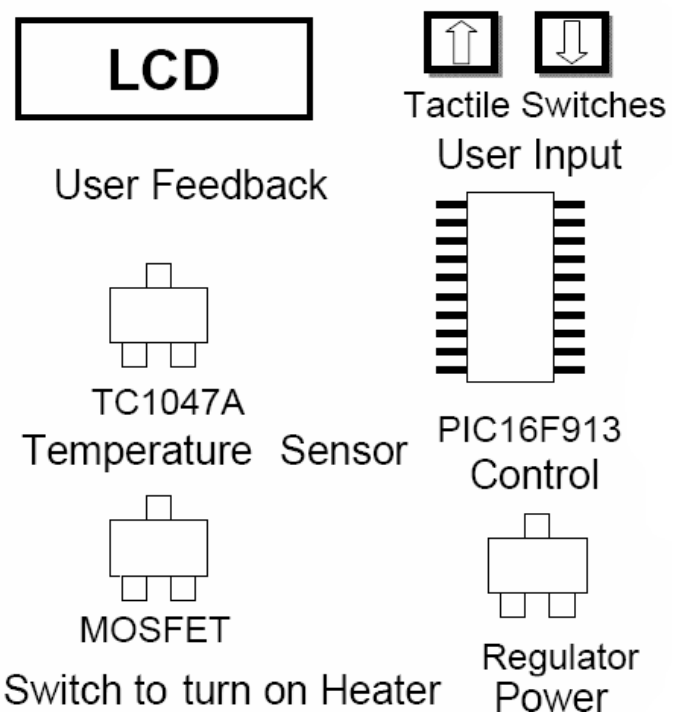
- Implementing electronics control in a mechanical system.
- Enhancing existing mechanical design with intelligent control.
- Replacing mechanical component with a electronic solution.

Real life applications: House hold thermostat

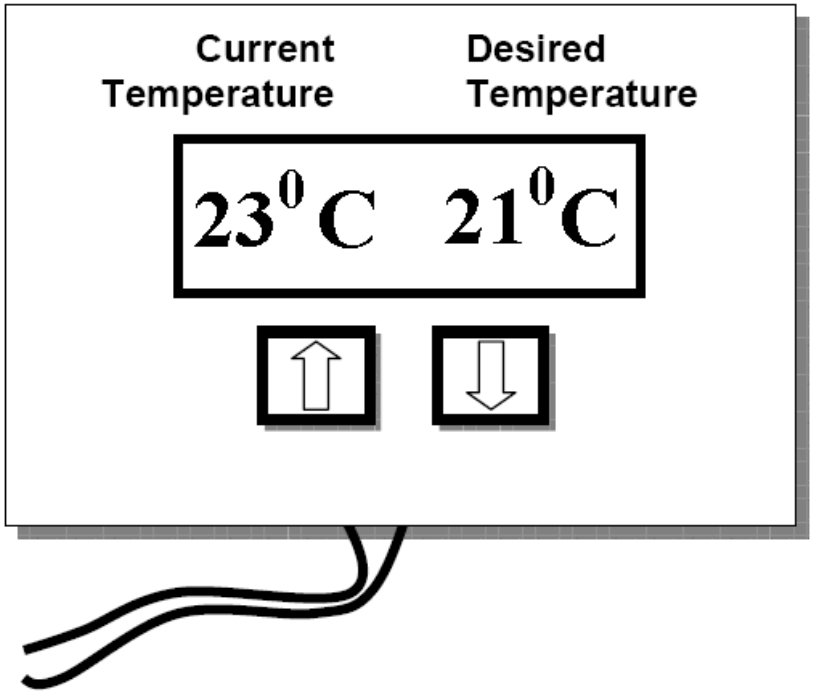

Desired Temperature
Dial
Current Temperature
60
50
70
40
80
80
70
60
50
40
Sensor/Switch
To Heating Unit

Thermostat components: Conversion to Mechatronic Design





Finished Design



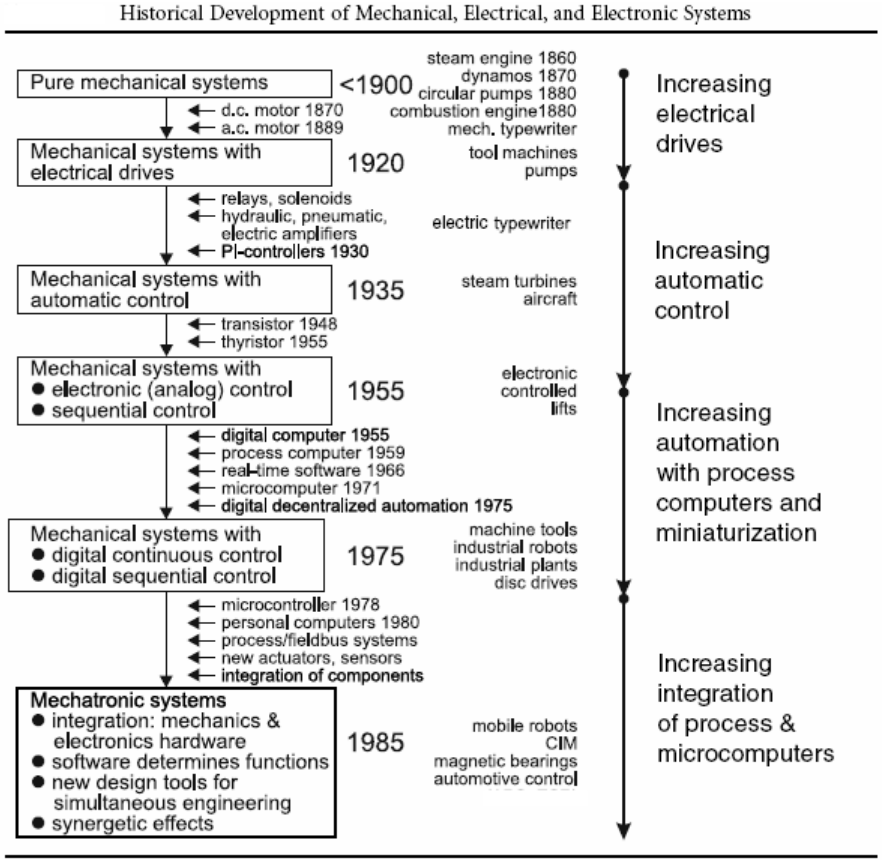
Classification of Mechatronics Products

- In the late 1970s, the Japan Society for the Promotion of Machine Industry (JSPMI) classified mechatronic products into
- Class I:
  - Primarily mechanical products with electronics incorporated to enhance functionality.
  - Examples include numerically controlled machine tools and variable speed drives in manufacturing machines.
- Class II:
  - Traditional mechanical systems with significantly updated internal devices incorporating electronics. The external user interfaces are unaltered.
  - Examples include the modern sewing machine and automated manufacturing systems.

- Class III:
  - Systems that retain the functionality of the traditional mechanical system, but the internal mechanisms are replaced by electronics.
  - An example is the digital watch.
- Class IV:
  - Products designed with mechanical and electronic technologies through synergistic integration.
  - Examples include photocopiers, intelligent washers and dryers, and automatic ovens.

- The enabling technologies for each mechatronic product class illustrate the progression of electromechanical products in stride with developments in control theory, computation technologies, and microprocessors.
- Class I products were enabled by servo technology, power electronics, and control theory.
- Class II products were enabled by the availability of early computational and memory devices and custom circuit design capabilities.
- Class III products relied heavily on the microprocessor and integrated circuits to replace mechanical systems.
- Class IV products marked the beginning of true mechatronic systems, through integration of mechanical systems and electronics.

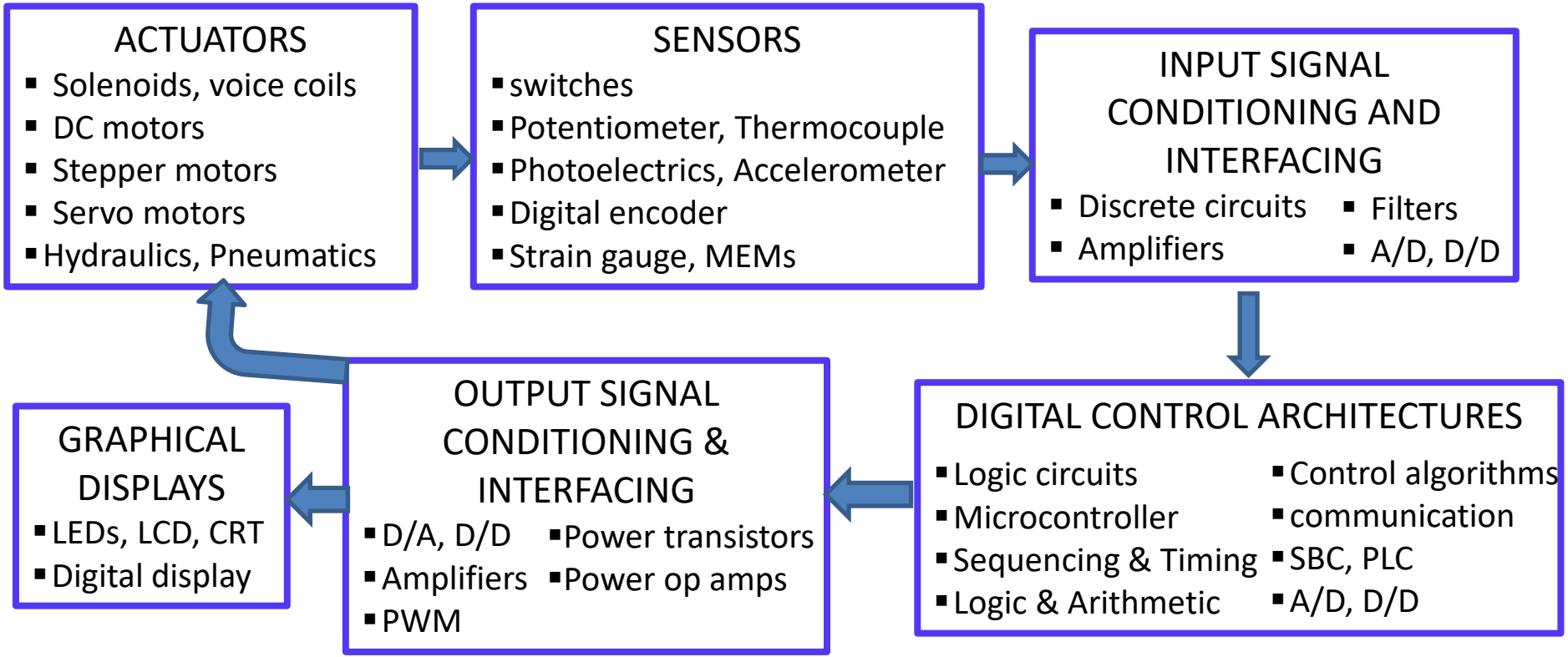
- It was not until the 1970s with the development of the microprocessor by the Intel Corporation that integration of computational systems with mechanical systems became practical.
- The electronic ignition system was one of the first mechatronic systems to be introduced in the automobile in the late 1970s.


Historical Development of Mechanical, Electrical, and Electronic Systems
Pure mechanical systems
<1900
steam engine 1860
dynamos 1870
circular pumps 1880
combustion engine1880
mech. typewriter
d.c. motor 1870
a.c. motor 1889
Mechanical systems with electrical drives
1920
tool machines
pumps
relays, solenoids
hydraulic, pneumatic, electric amplifiers
PI-controllers 1930
electric typewriter
Mechanical systems with automatic control
1935
steam turbines
aircraft
transistor 1948
thyristor 1955
Mechanical systems with
electronic (analog) control
sequential control
1955
electronic controlled lifts
digital computer 1955
process computer 1959
real-time software 1966
microcomputer 1971
digital decentralized automation 1975
Mechanical systems with
digital continuous control
digital sequential control
1975
machine tools
industrial robots
industrial plants
disc drives
microcontroller 1978
personal computers 1980
process/fieldbus systems
new actuators, sensors
integration of components
Mechatronic systems
integration: mechanics & electronics hardware
software determines functions
new design tools for simultaneous engineering
synergetic effects
1985
mobile robots
CIM
magnetic bearings
automotive control
Increasing electrical drives
Increasing automatic control
Increasing automation with process computers and miniaturization
Increasing integration of process & microcomputers

Benefits of Mechatronics

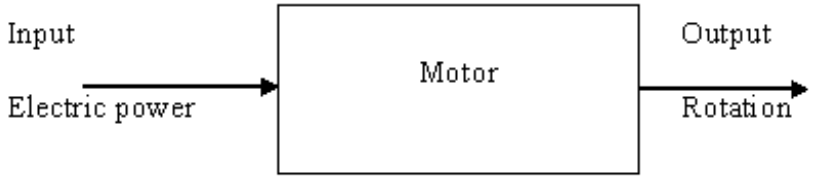
- More features
- Higher precession
- User friendly
- More flexible
- Lower cost, Efficient
- Environment friendly
- Smaller geometry
- More reliable
- Safer

Mechatronic system components



System

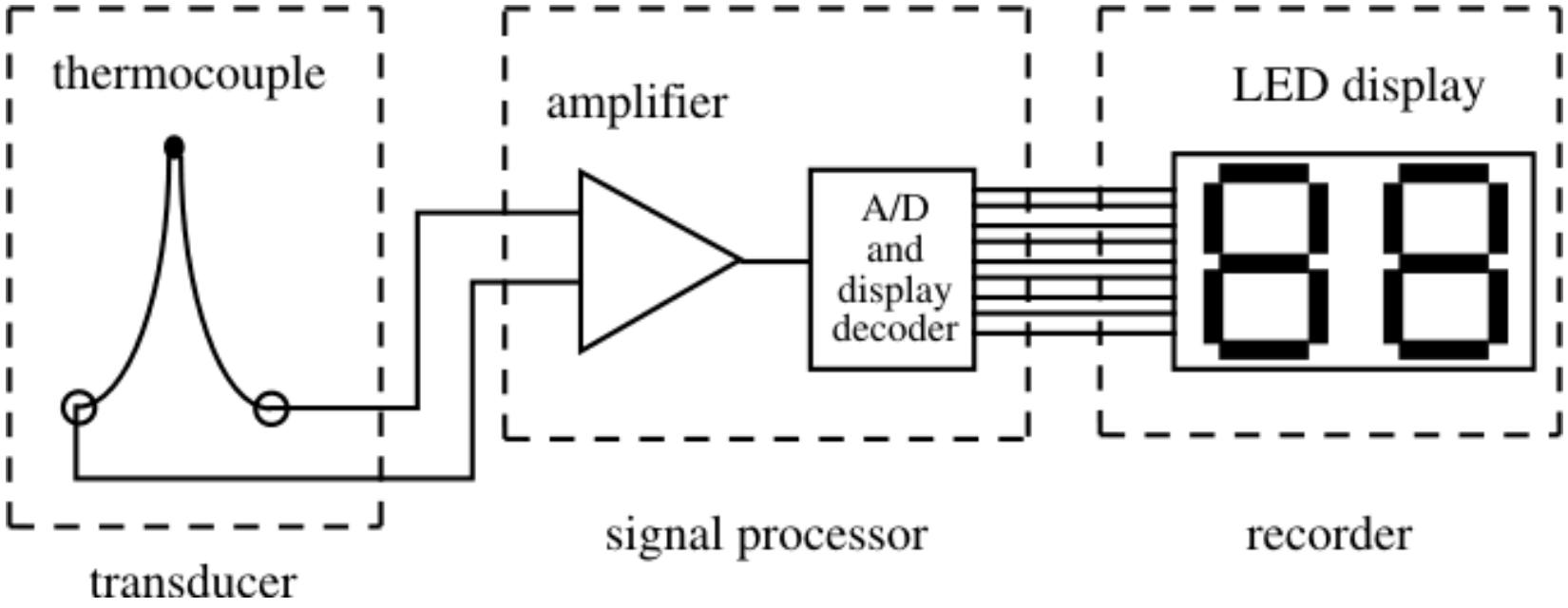
- System can be thought of as a box which has an input and an output and where we are not concerned with what goes on inside the box but only the relationship between the output and the input.



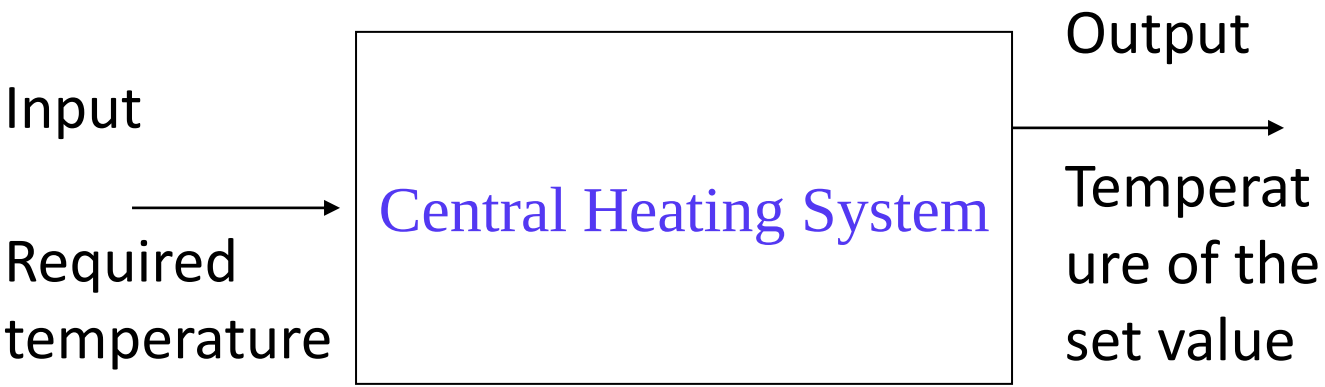
Measurement System

- A black box used for making measurements.
- It has the input the quantity being measured and output the value of the quantity.
- Example: temperature measurement system

An Example of Measurement System



A control system

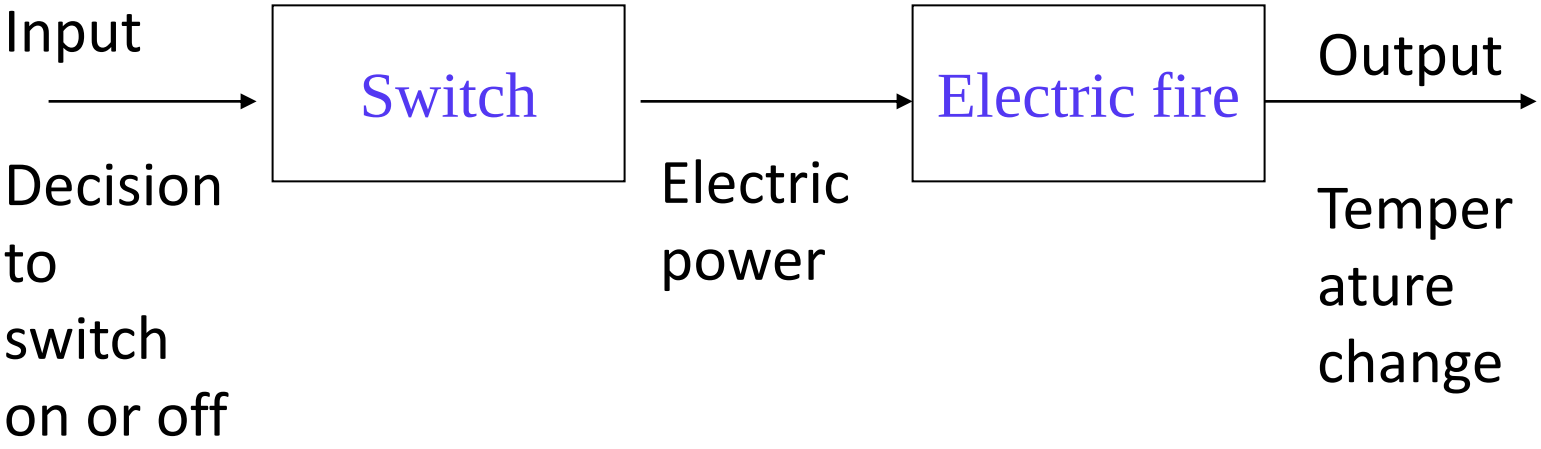


Control System

- Open loop systems

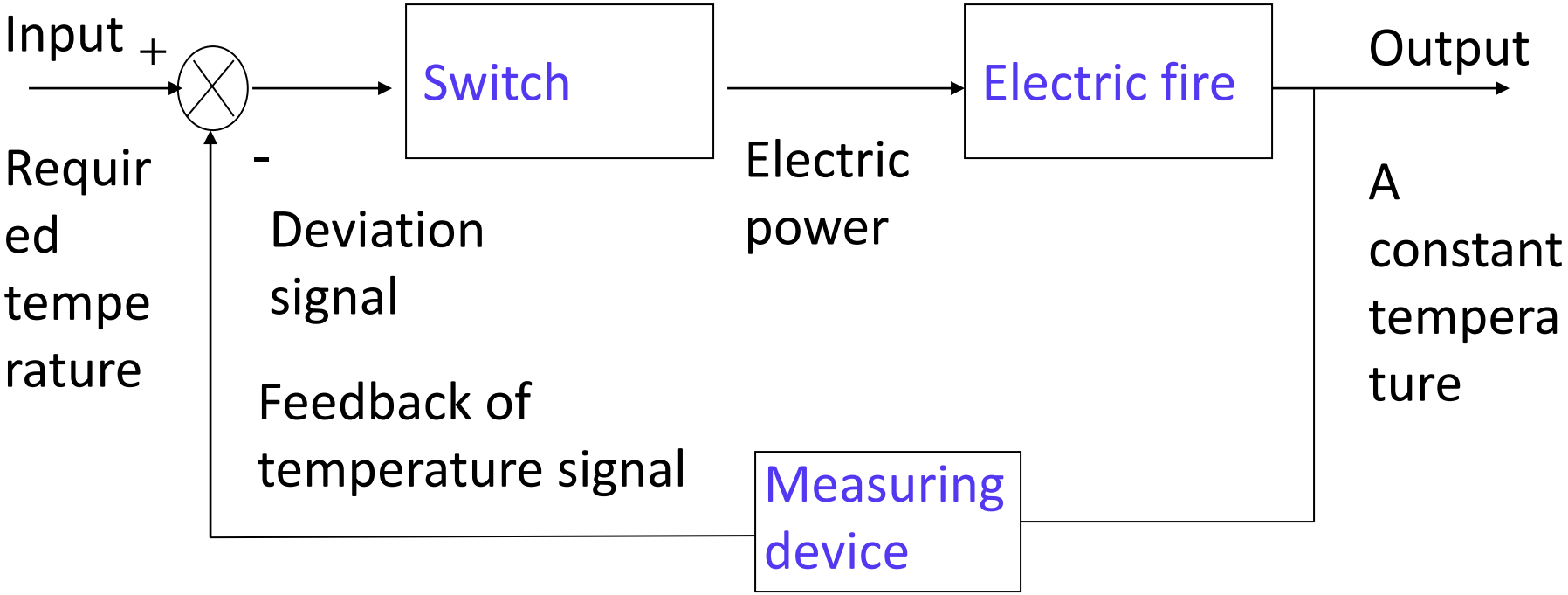
- Closed loop systems

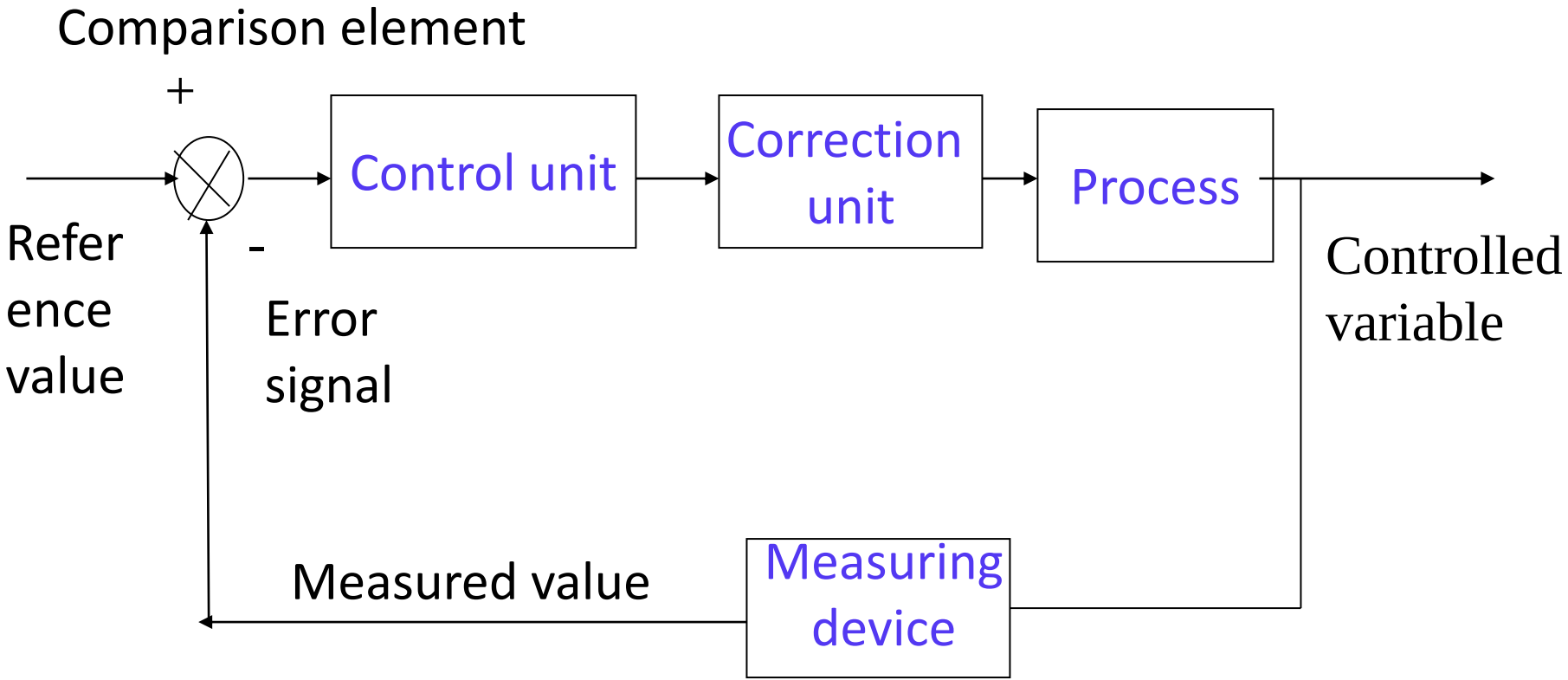
Open Loop System



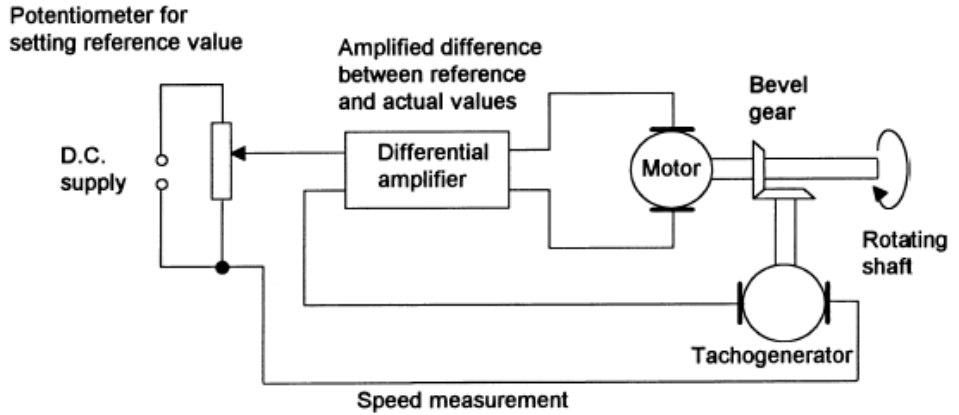
Elements of a closed loop system

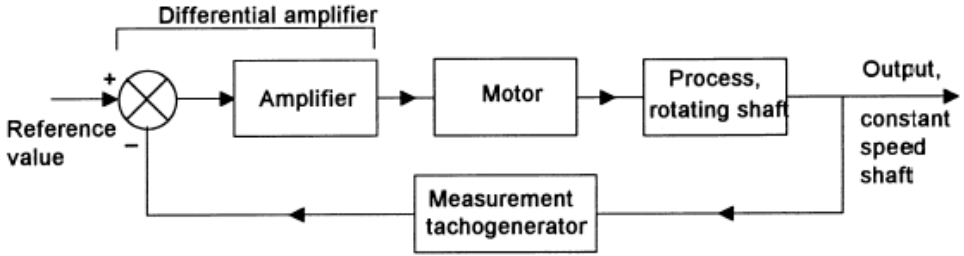
Comparison element




Comparison element
+
-
Control unit
Correction unit
Process
Refer ence value
Error signal
Controlled variable
Measured value
Measuring device

Shaft Speed Control (Closed loop system)





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Thank You