



ROBOTICS ELECTRICAL SYSTEMS

Robotic Control System

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Control System

- A Control System consists of devices or set of devices, that manages, commands, directs or regulates the behavior of other device(s) or system(s) to achieve desired results.
- Control systems continually make adjustments to alter machine operations
- A control system is a system, which controls other systems.

Open Loop Control System

A control system in which the control action is totally independent of output of the system then it is called **open loop control system**



Open loop Control system normally depends on time slice. Each action divides in set of times to produce the desire results

Example of Open Loop System

- **Electric Hand Drier** – Hot air (output) comes out as long as you keep your hand under the machine, irrespective of how much your hand is dried.
- **Automatic Washing Machine** – This machine runs according to the pre-set time irrespective of washing is completed or not.
- **Bread Toaster** – This machine runs as per adjusted time irrespective of toasting is completed or not.
- **Automatic Tea/Coffee Maker** – These machines also function for pre adjusted time only.
- **Timer Based Clothes Drier** – This machine dries wet clothes for pre – adjusted time, it does not matter how much the clothes are dried.
- **Traffic Signals**- Signals turn on or off irrespective the load of traffic

Advantages and Disadvantages of an Open Loop Control System

Advantages

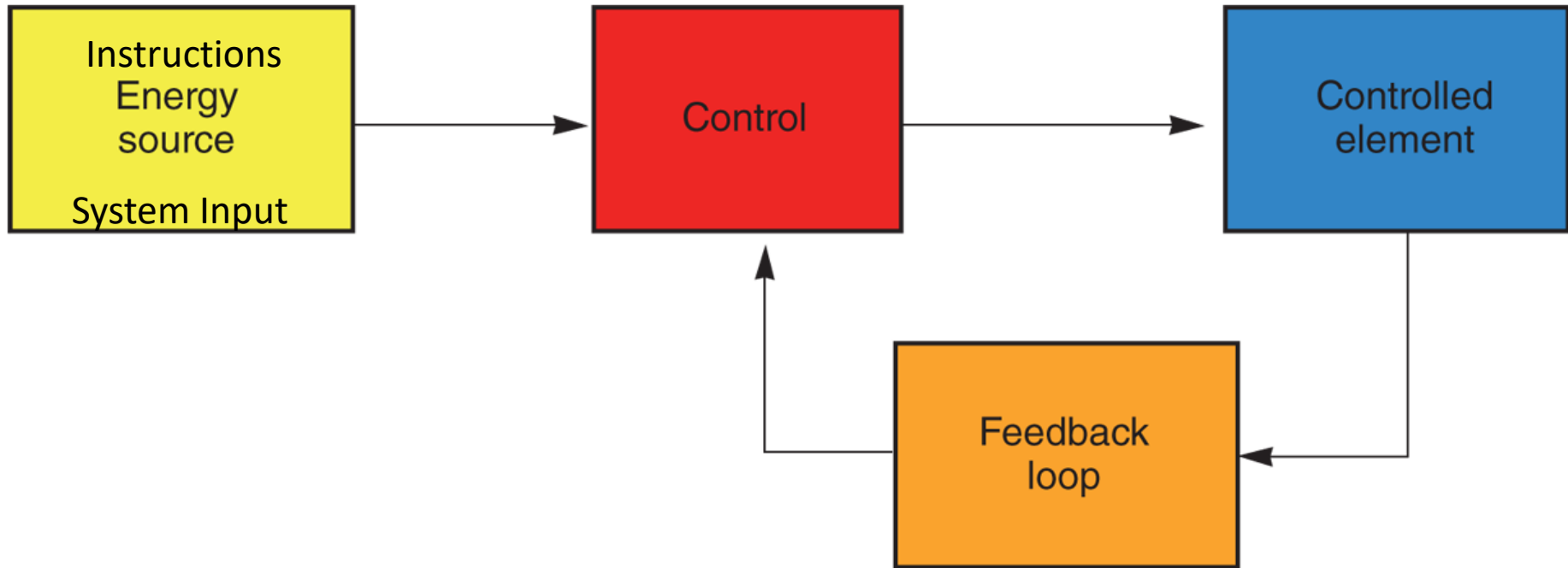
- Simple in construction and design.
- Economical.
- Easy to maintain.
- Generally stable.
- Convenient to use as output is difficult to measure.

Disadvantages

- They are inaccurate.
- They are unreliable.
- Any change in output cannot be corrected automatically.

Control Systems

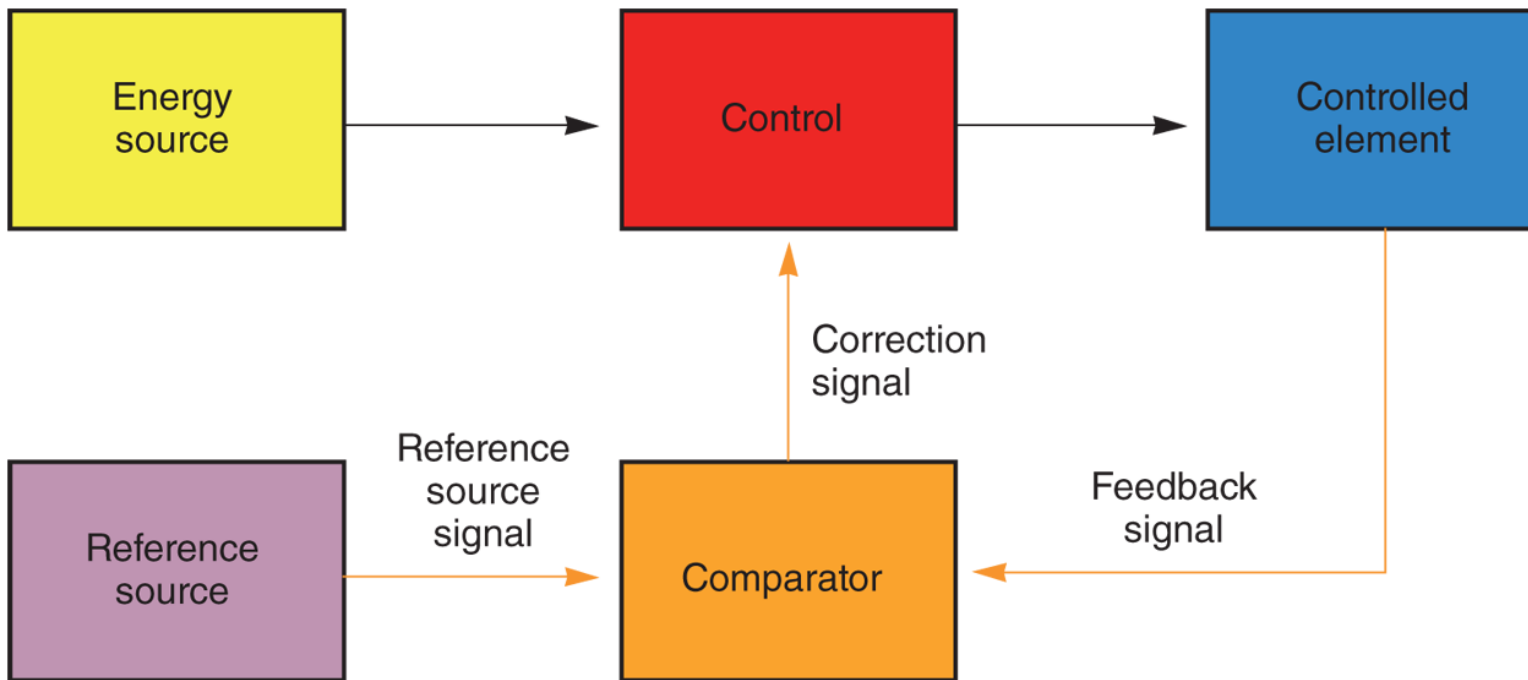
- Closed-loop system incorporates feedback



Open loop control system can be converted in to closed loop control system by providing a feedback

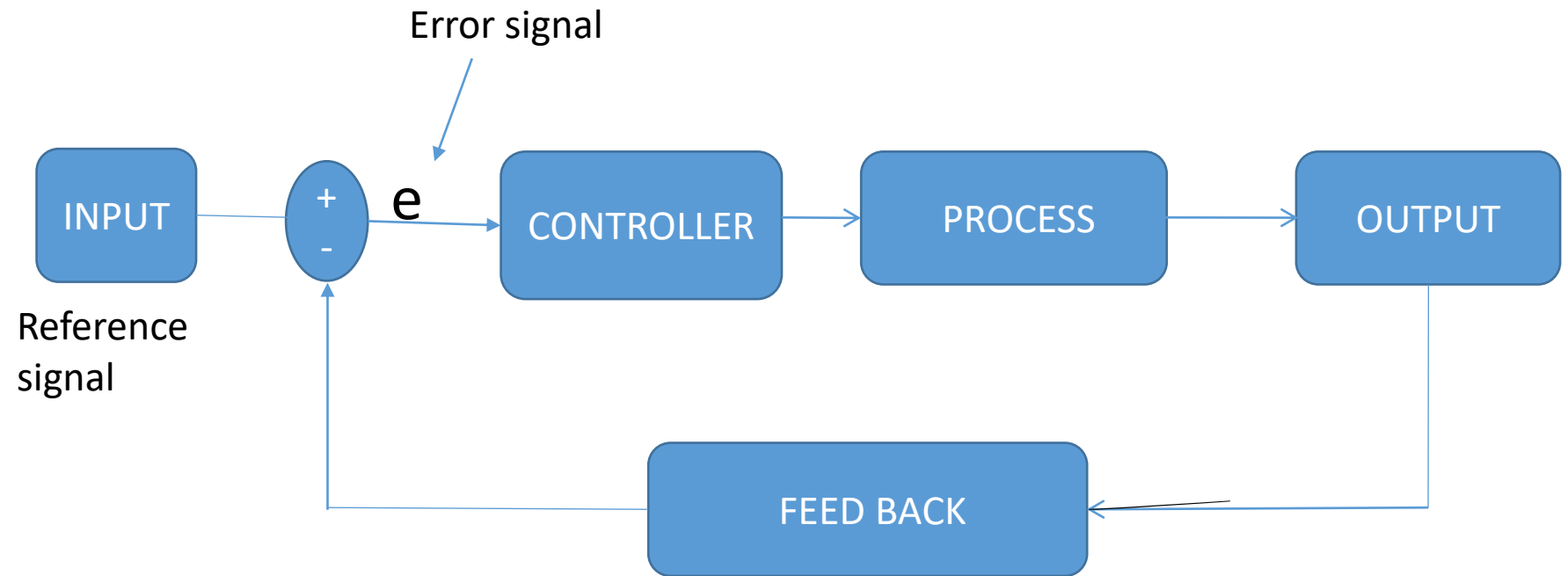
Close Loop Control Systems

- Comparator in closed-loop control system



Closed-loop system with automatic correction control. *Comparator* compares feedback signal to reference signal or standard Correction signal sent to control unit

Close Loop Control System



Closed-loop system allows the interaction between the control unit and controlled elements (process, output). *Feedback* provides information using sensors (electrical, thermal, light, chemical, or mechanical)

Examples of Closed Loop Control System

Automatic Electric Iron – Heating elements are controlled by output temperature of the iron.

Water Level Controller– Input water is controlled by water level of the reservoir.

Missile Launched & Auto Tracked by Radar – The direction of missile is controlled by comparing the target and position of the missile.

An Air Conditioner – An air conditioner functions depending upon the temperature of the room.

Thermostat Heater– It operates depending upon the temperature which it controls.

Automated Machines/ Robotic Arm: All motions have feedback in term of displacement / velocity / acceleration

Advantages and Disadvantages Of Closed Loop Control System

Advantages

- Highly accurate as any error arising is corrected due to presence of feedback signal.
- Facilitates automation
- This system is less affected by External disturbances

Disadvantages

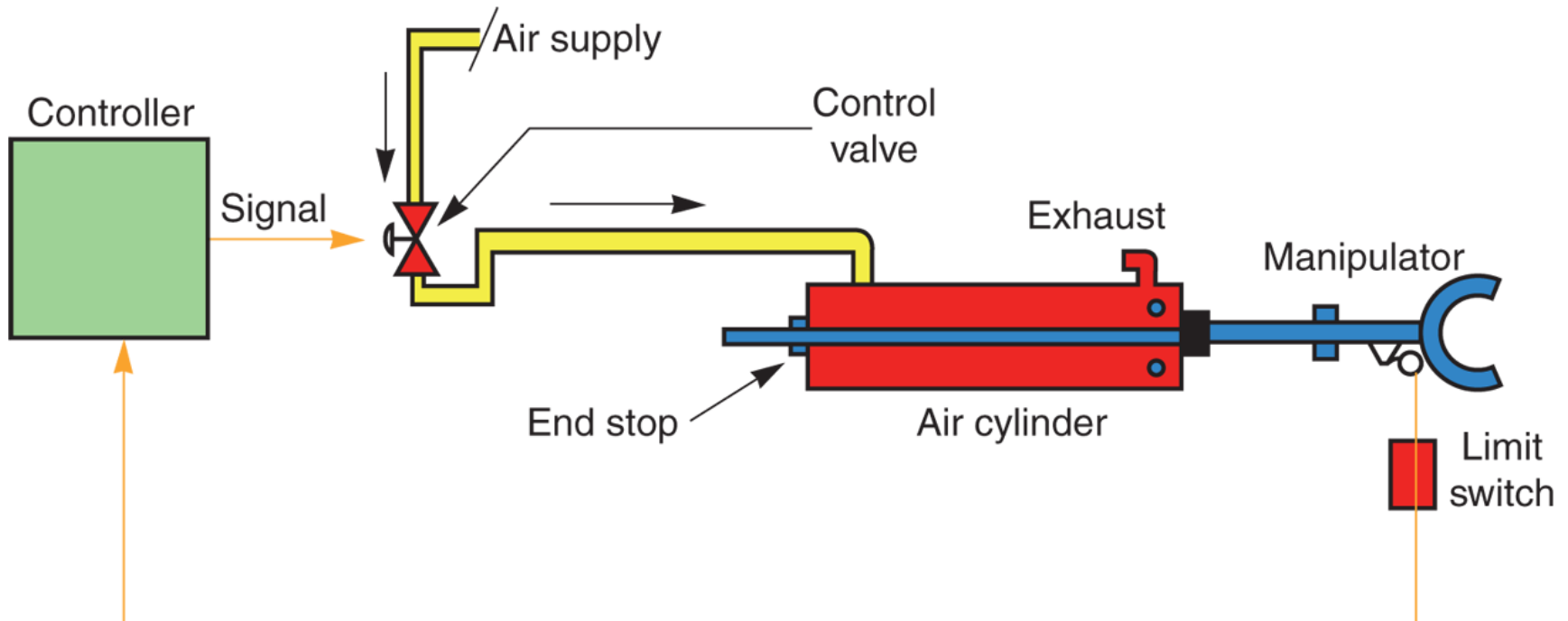
- They are costlier
- They are complicated to design
- Required more maintenance
- Stability is the major problem and more care is needed to design a stable closed loop system

Types of Control Systems in Robotics

- Non-servo Robots – Open Loop Control Systems
- Servo Robots – Close Loop control systems

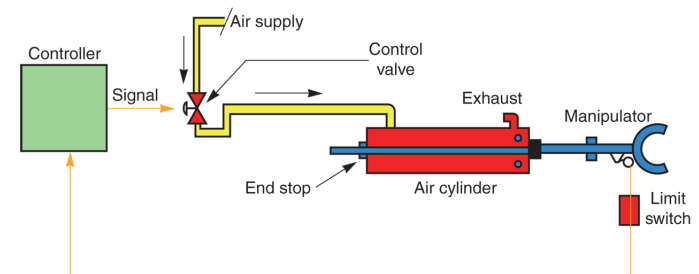
Non Servo Robot - Control Systems

- Limit switch can control movement in non-servo systems
 - *Open-loop system* has no feedback to compare positions
 - Limited movement using mechanical stops

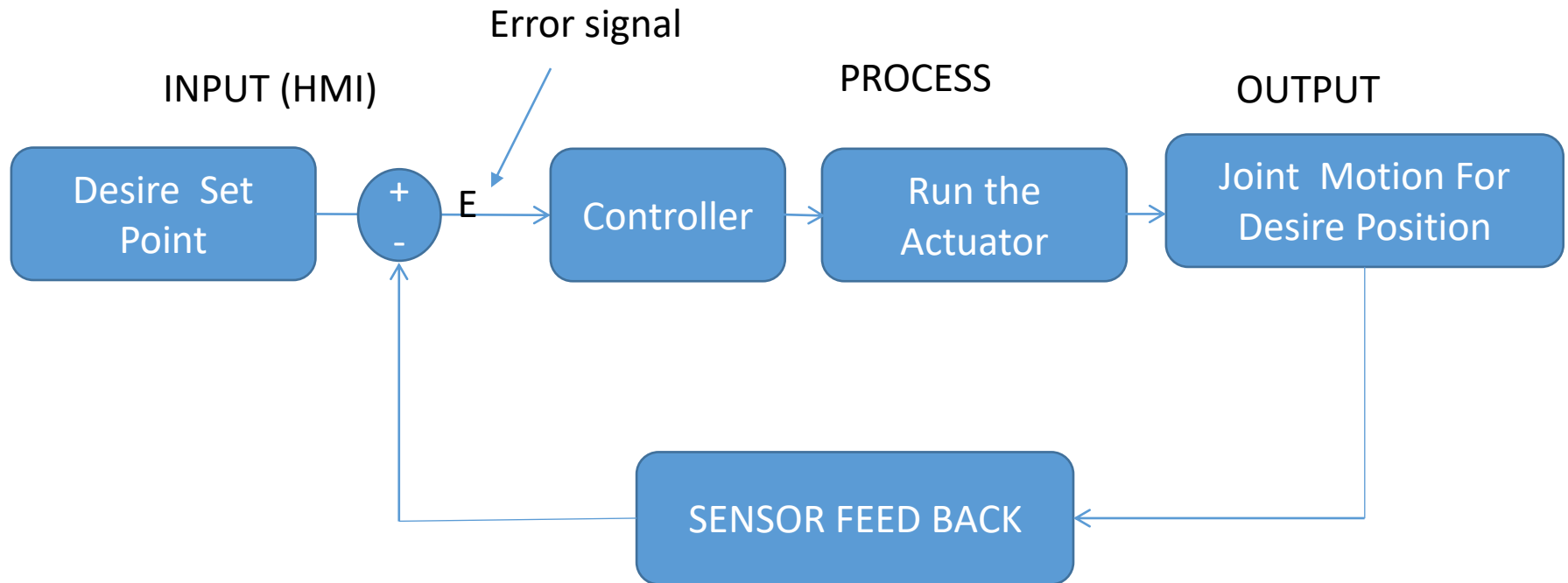


Non- Servo Robot

- At the beginning of the cycle, the controller sends a signal to the control valve of the manipulator.
- As the valve opens, air passes into the air cylinder and causes the rod in the cylinder to move. As long as the valve remains open, this rod continues to move until it is restrained by the end stop.
- After the rod reaches the limit of its travel, a limit switch tells the controller to close the control valve.
- The controller sends the control valve a signal to close
- The controller then moves to the next step in the program and imitates the necessary signals

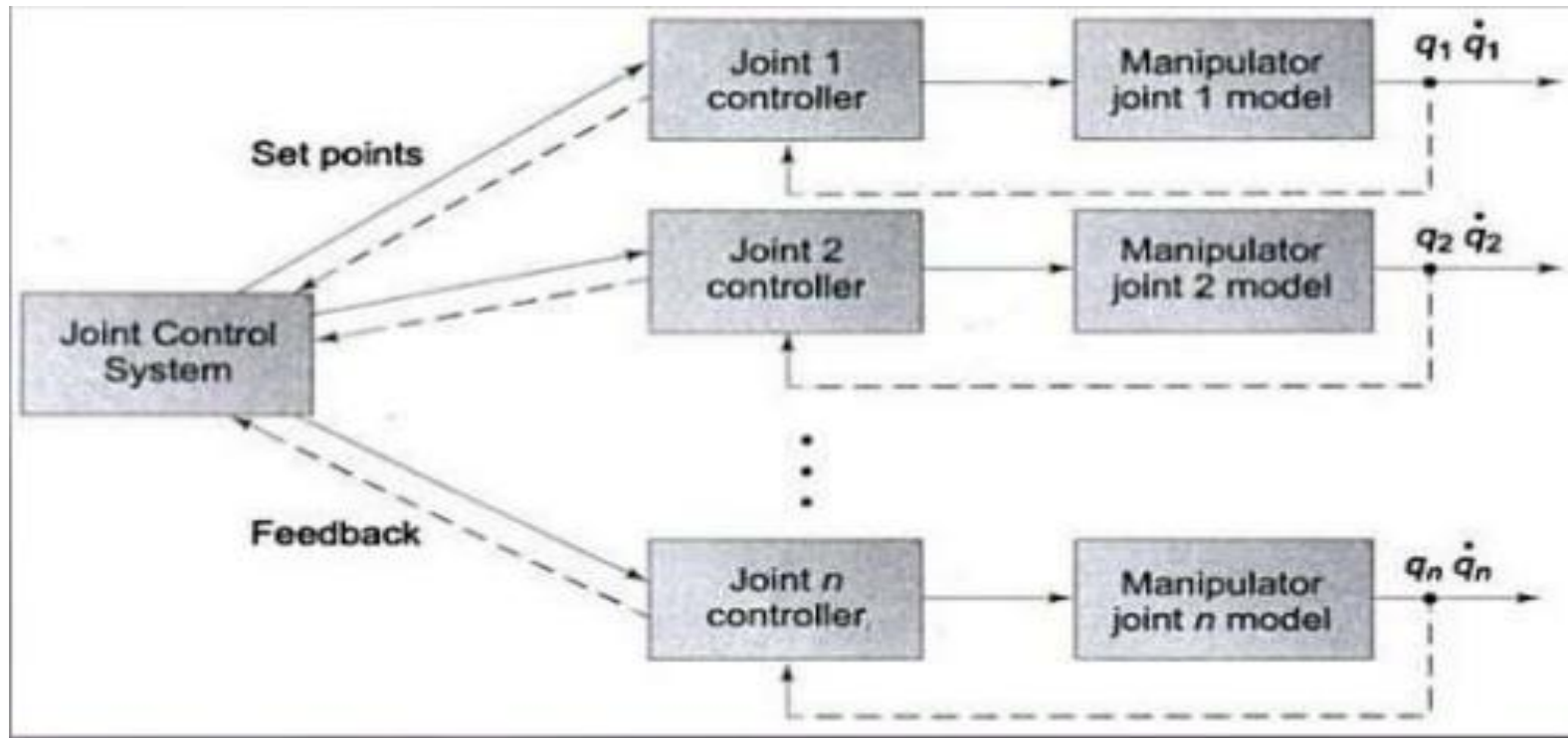


Servo Robot - Close Loop Control System for a Robotic Arm



Control unit determines robot flexibility and efficiency by achieving the desired position

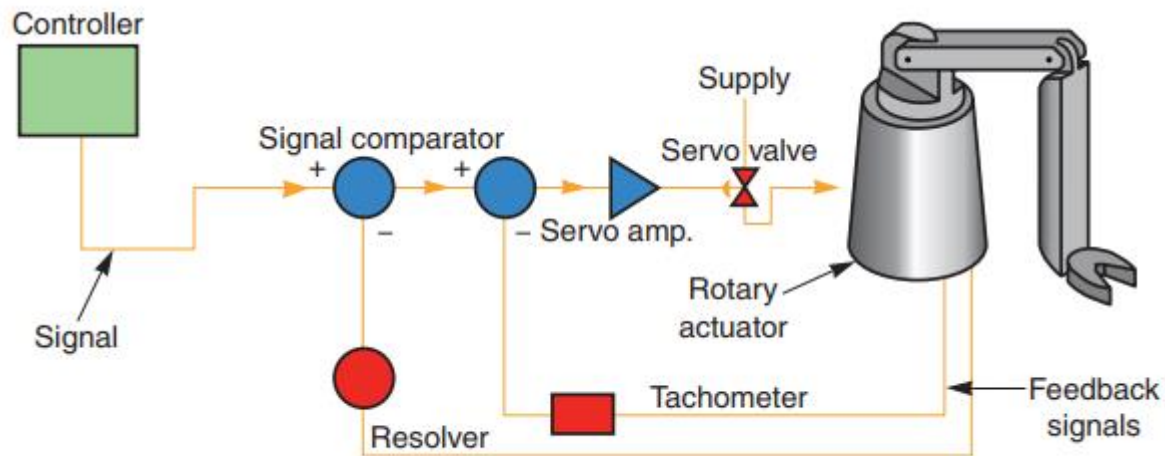
Joint Control Systems with Multiple Joints



Resource: Motorman Manual Controller DX 100

Servo Robot System

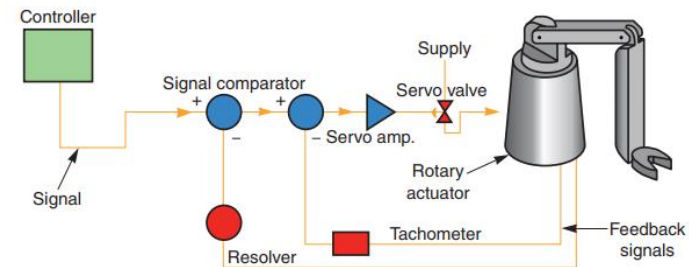
- *Servo robots* use a closed-loop system
 - *Closed-loop system* allows feedback to affect output
 - *Servo amplifier* translates feedback signals from controller
 - Servomechanism detects and corrects for errors



Servo Robot System

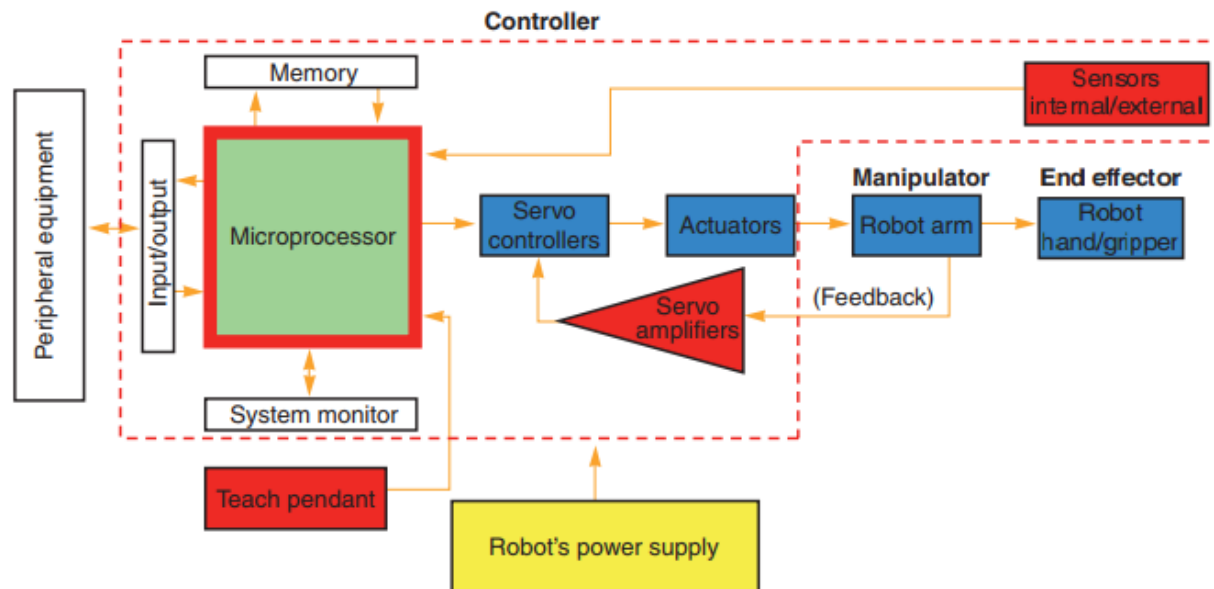
1. When the cycle begins, the controller search the robot's programming for the desired location along each axis
2. Using the feedback signals, the controller determines the actual locations on the various axes of the manipulator.
3. The desired locations and actual locations are compared.
4. When these locations do not match, an error signal is generated and sent back to the servo amplifier.
5. These error signals are transformed by the servo amplifier and applied to the control valve on the appropriate axis
6. The valve opens in proportion to the intensity of the signal received. The opened valve admits fluid to the proper actuator to move the various segments of the manipulator.
7. New signals are generated as the manipulator moves.
8. The servo control valves close when there are no more error signals, shutting off the flow of fluid.
9. The manipulator comes to rest at the desired position.
10. The controller then addresses the next instruction in the program, which may be to move to another location or operate some peripheral equipment.

The process is repeated until all steps of the program are completed.



Servomechanism - Servo Controller

A servomechanism is a type of control system that detect and correct the errors. A robot that uses this type of system is called a servo robot. In this system, the feedback signal is sent to the servo amplifier. A servo amplifier is a device that translates signals from the controller into motor voltage and current signals. Servo amplifiers are used in motion control system where precise control of position or velocity is necessary.



Servo Motor

- Servo motor is an example of a servo control system.
- Each joint of a servo robot is controlled using a servo motor.
- Servo motor consists of:
 - Servo Driver
 - Electrical motor
 - Feedback System (Encoders)

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Source: Mitsubishi motor

Servo Driver

- Servo driver gives the input signal to the motor and take the feedback signal from the encoders



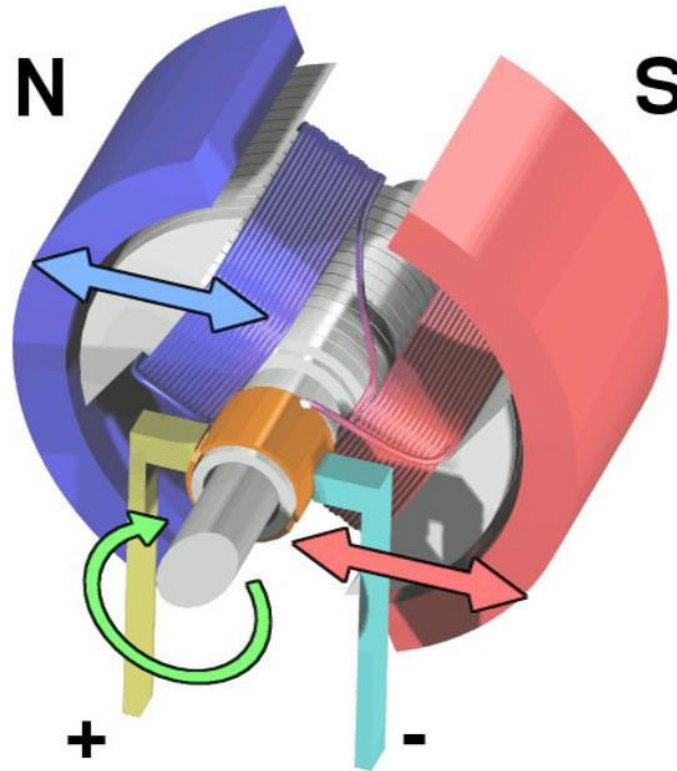
Source: www.jss-motor.com

Electric Motor

A servo motor consists of simple DC or AC motor



Robotshop.com

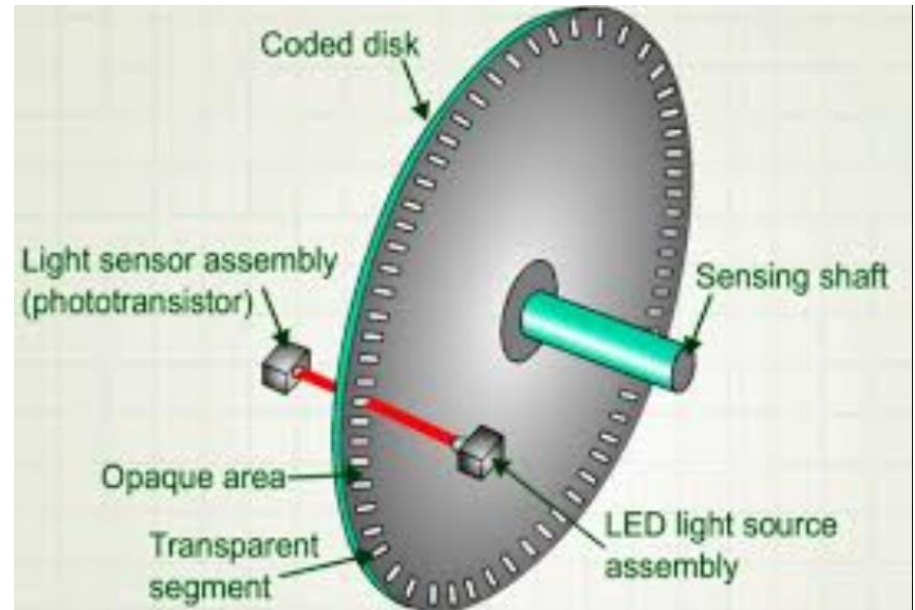


WE WILL TALK ELECTRIC
MOTOR IN DETAILS LATER in
WEEK 08 / WEEK 09

Encoders - Angular Position and Velocity Sensors

Encoders

Encoder consists of a disk which has number of slits. The light passes through the slit and hits the light sensor. In result a single pulse is generated.



Incremental Encoder

Source: ResearchGate (Dipam Chakraborti)

Review Questions for Discussion

- Q1. What are the two types of control systems used to classify robots? What is the main difference between the two types of control systems?
- Q2. What type of robots are considered open-loop systems? Explain what open-loop means.
- Q3. What type of robots are considered closed-loop systems? Explain what close-loop means.
- Q4. Sketch the diagram of close loop system and explain how it works.
- Q5. what is the Servomechanism system and how the servo amplifiers works ?