Basic Mechatronics Workshop

Module 1:Introduction to Mechatronics

Lecture-2

Basic concepts of control systems

(Pilot & Memory, Sequence, Time Schedule)

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Lecture-2

Basic concepts of control systems
(Pilot & Memory, Sequence, Time Schedule)

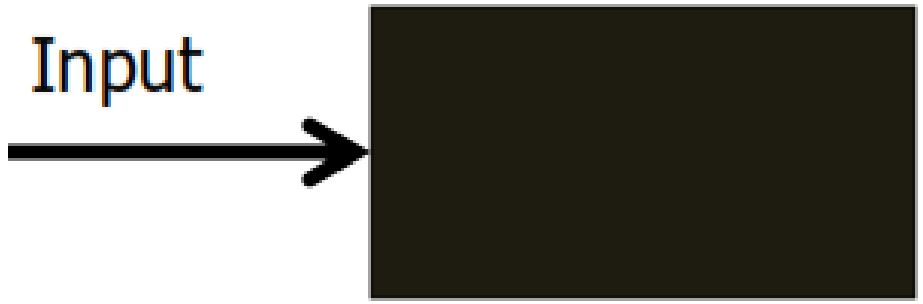
Objectives

Upon completion of this chapter, Student should be able to

1. Understand the basic concepts of control of systems.
2. Understand manual and automatic control operation
3. List the criteria for a working and control medium.
4. Understand Control types according to DIN 19226
5. Understand the basic concepts of pilot & memory, sequence, time schedule.
6. State the control system development.

Control System Overview

Input

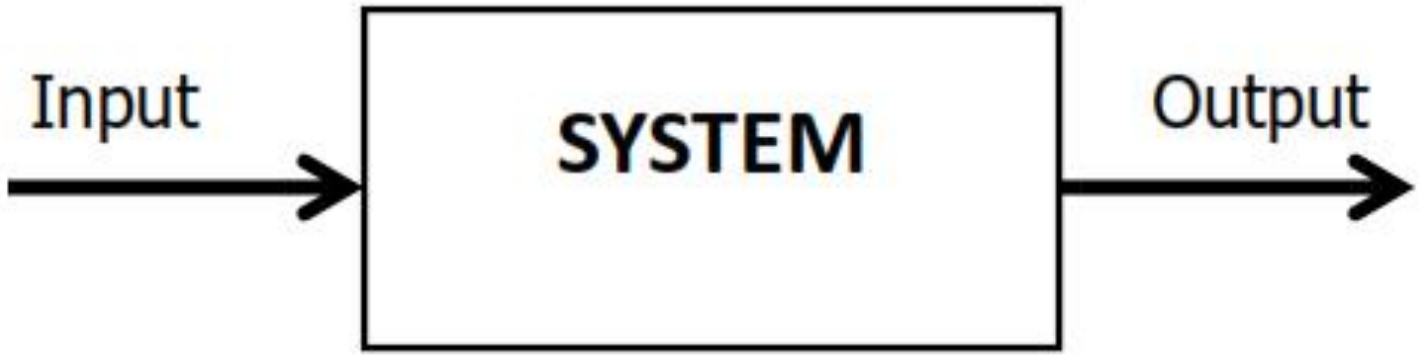


- The stimulus or excitation applied to a control system from an external source in order to produce the output is called input

Output

- The actual response obtained from a system is called output.

"System"



- A system is an arrangement of or a combination of different physical components connected or related in such a manner so as to form an entire unit to attain a certain objective.

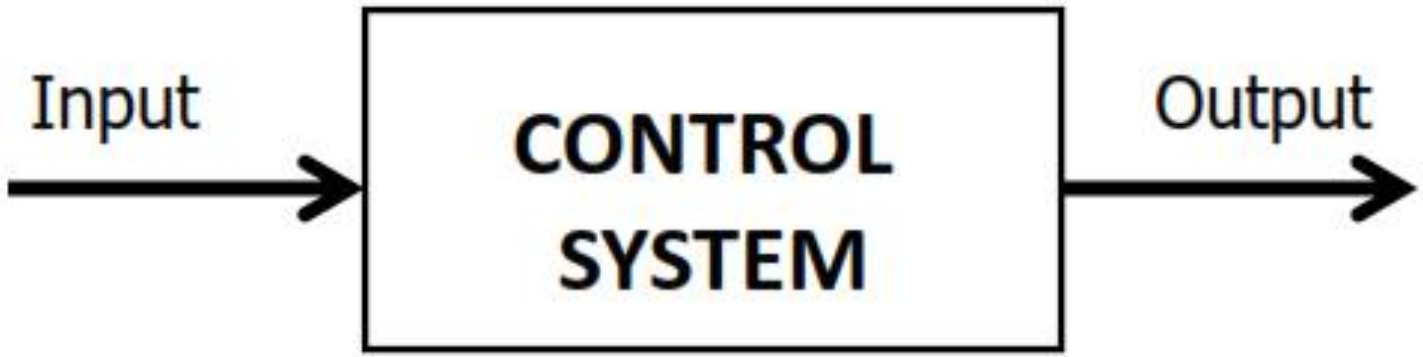
Control

- It means to regulate, direct or command a system so that the desired objective is attained

Combining above definitions

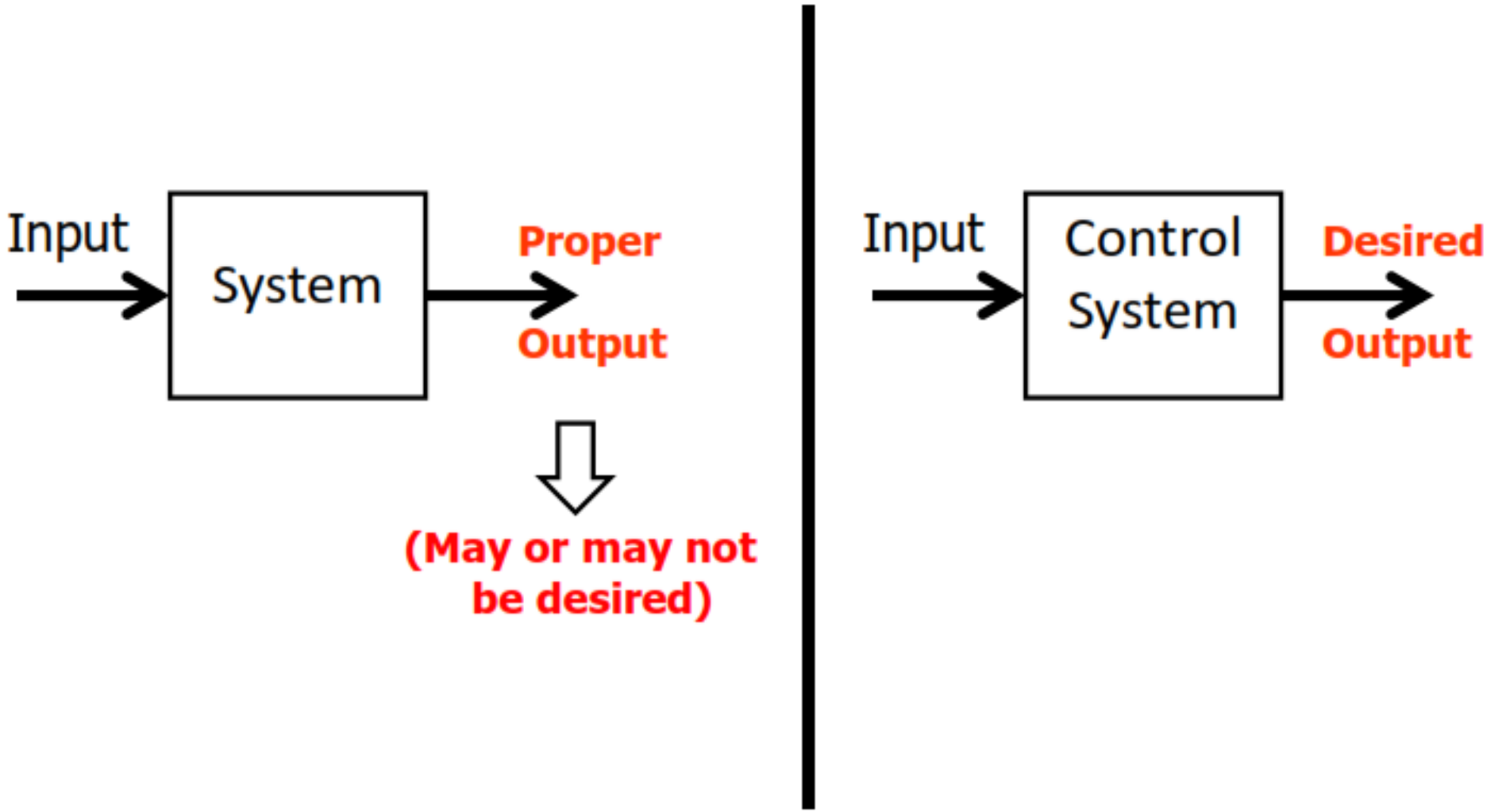
System + Control = Control System

Control System



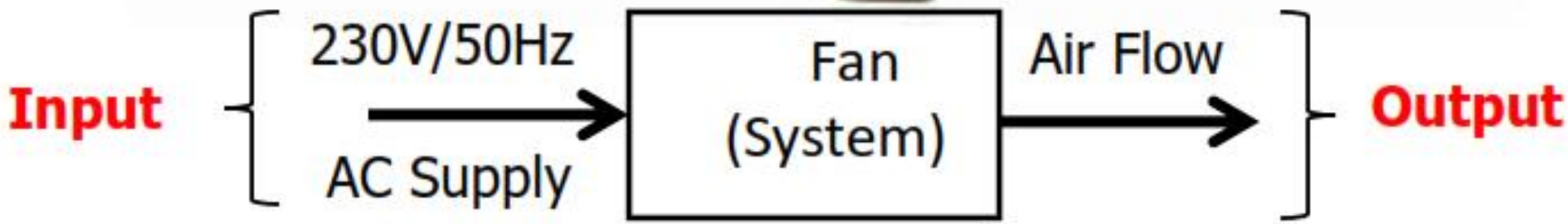
- It is an arrangement of different physical elements connected in such a manner so as to regulate, direct or command itself to achieve a certain objective.

Difference between System and Control System



Difference between System and Control System

An example : Fan



A Fan: Can't Say System

- A Fan without blades cannot be a "SYSTEM"

  Because it cannot provide a desired/proper output

  i.e. airflow

Input

230V/50Hz

AC Supply

Output

No Airflow

(No Proper/ Desired Output)

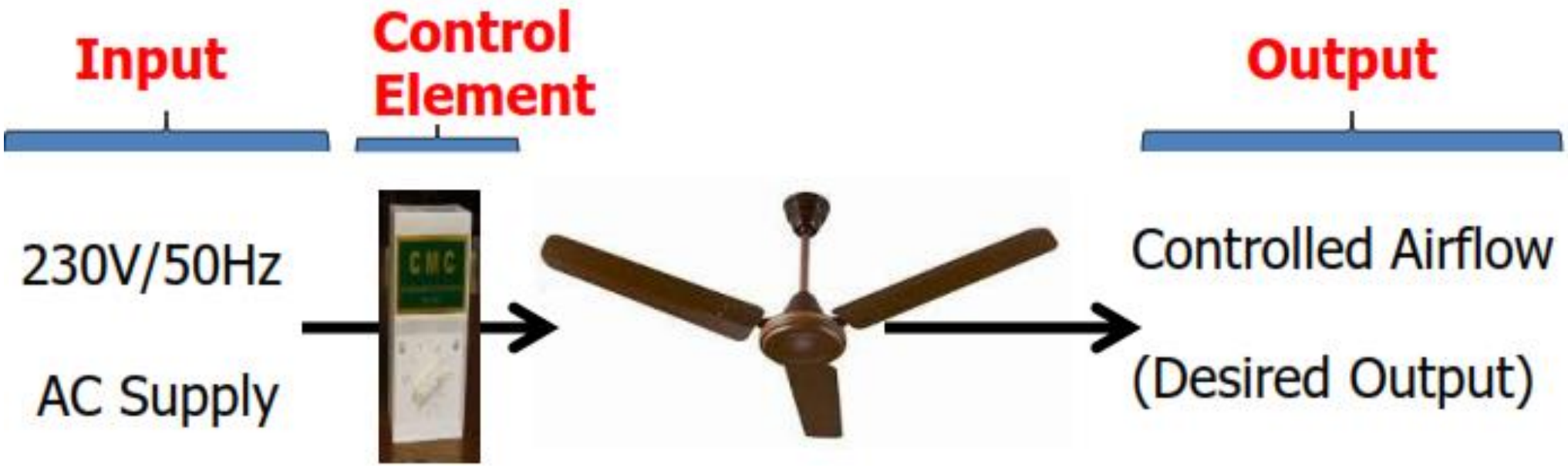
A Fan: Can be a System

- A Fan with blades but without regulator can be a "SYSTEM"
  Because it can provide a **proper output** i.e. airflow
- But it cannot be a "Control System" Because it cannot provide desired output i.e. controlled airflow

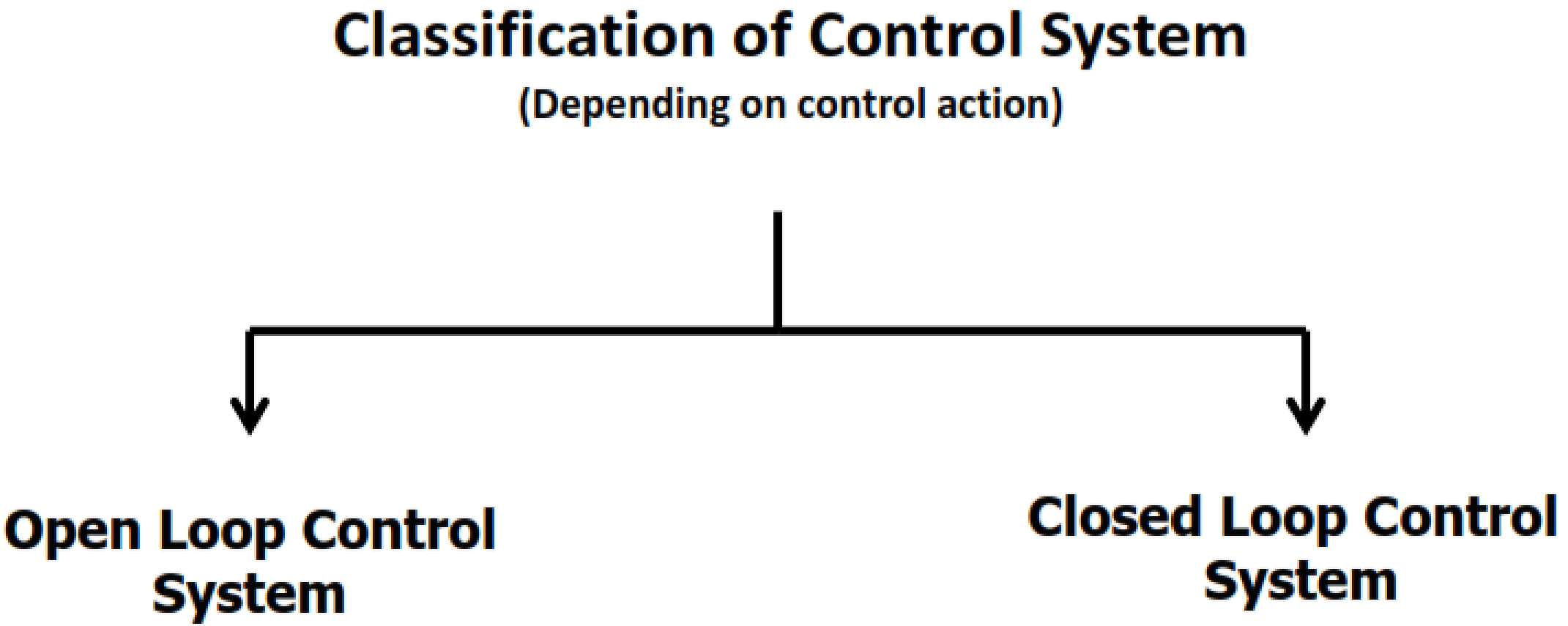
A Fan: Can be a Control System

- A Fan with blades and with regulator can be a "CONTROL SYSTEM" Because it can provide a **Desired output.**

  i.e. Controlled airflow



Classification of Control System



Open Loop Control System

Definition:

"A system in which the control action is totally independent of the output of the system is called as open loop system"

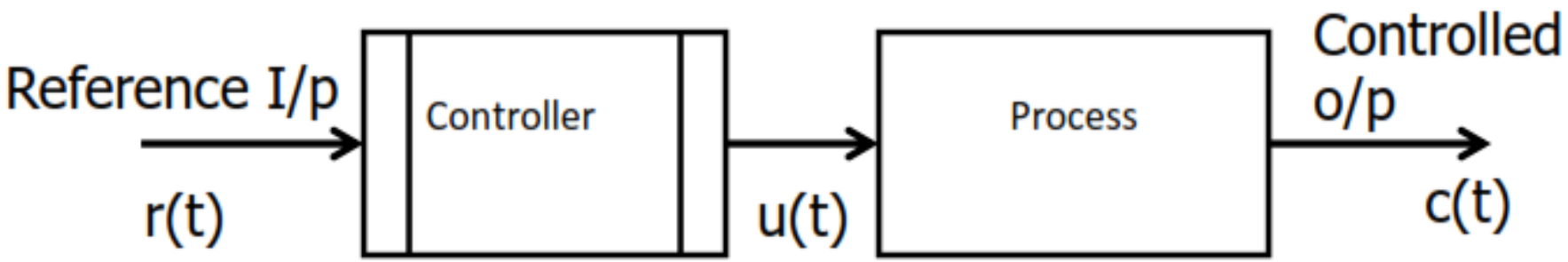


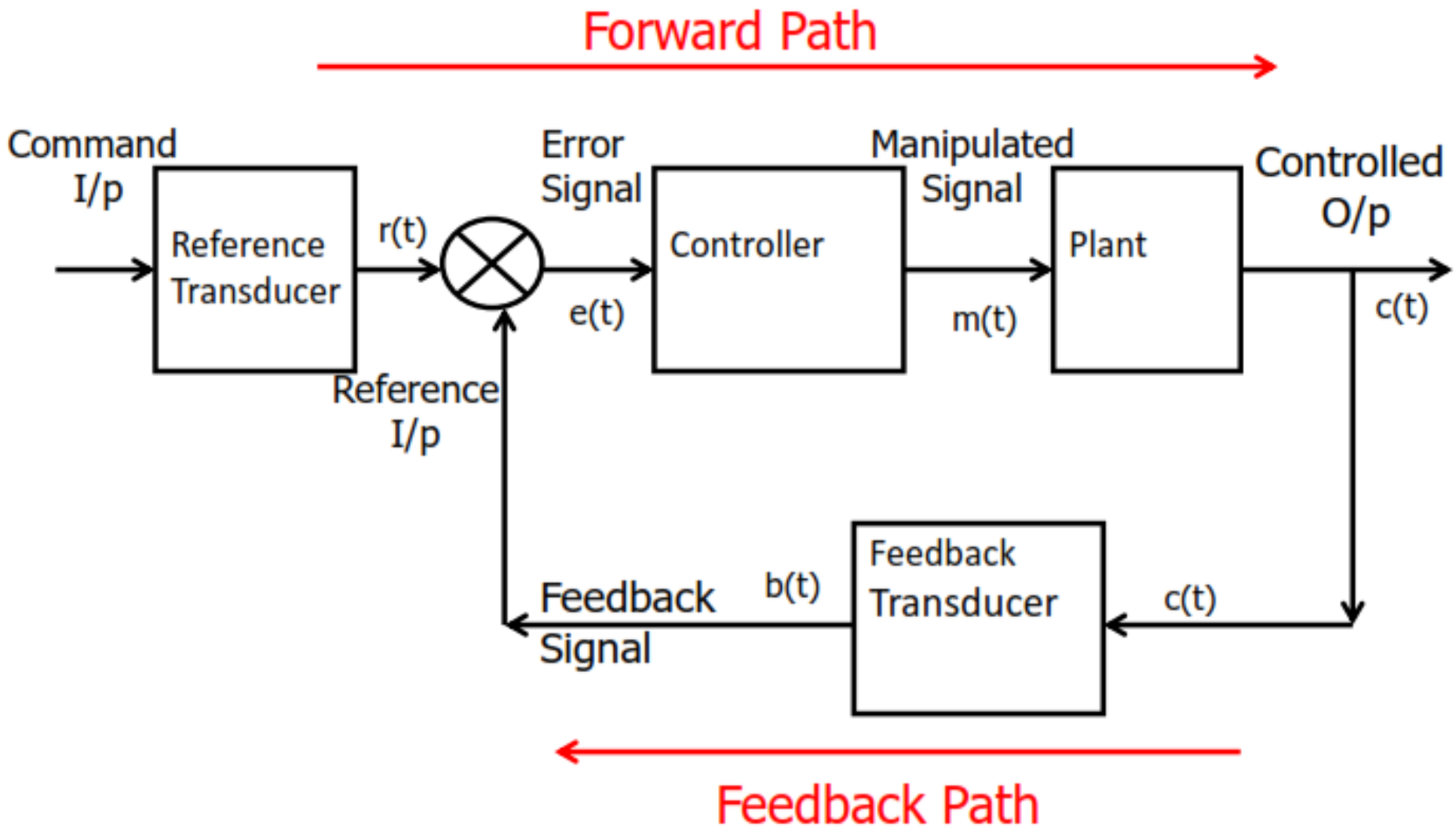
Fig. Block Diagram of Open loop Control System

Closed Loop System

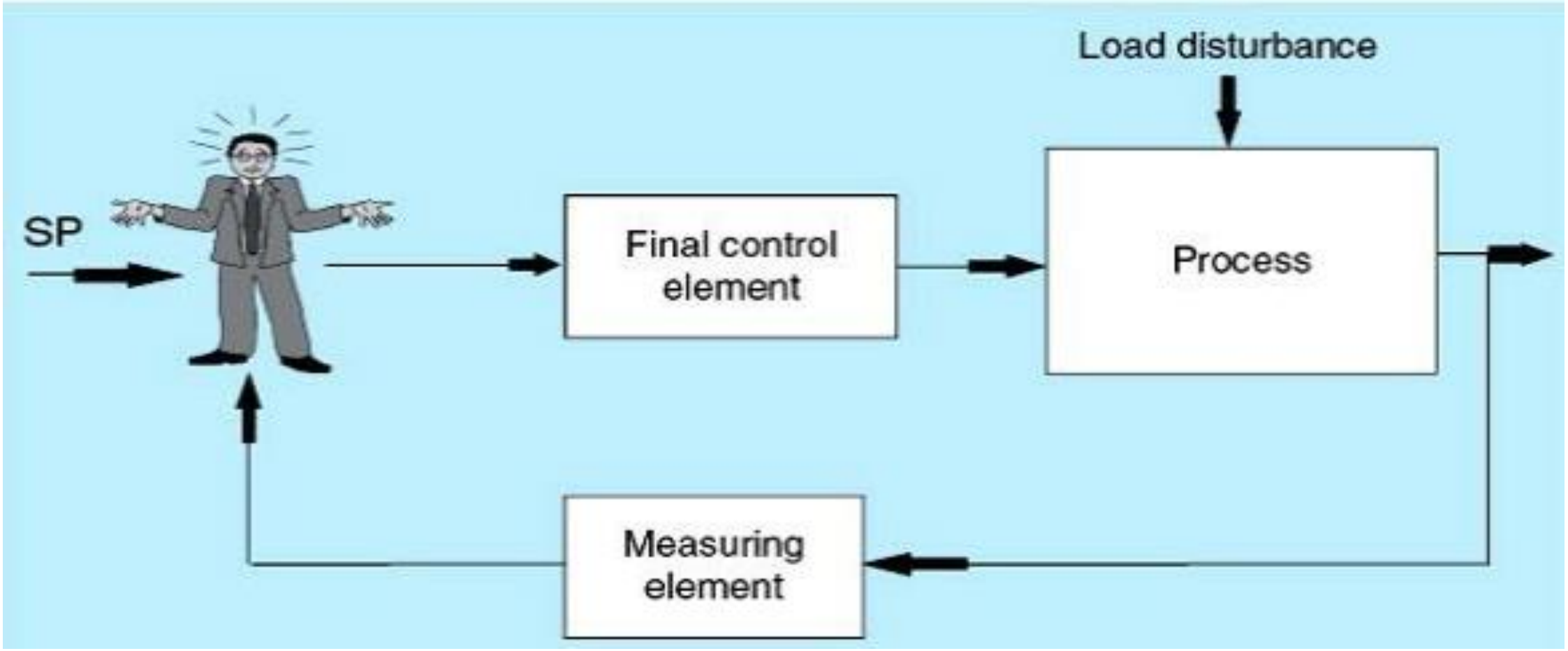
Definition:

"A system in which the control action is somehow dependent on the output is called as closed loop system"

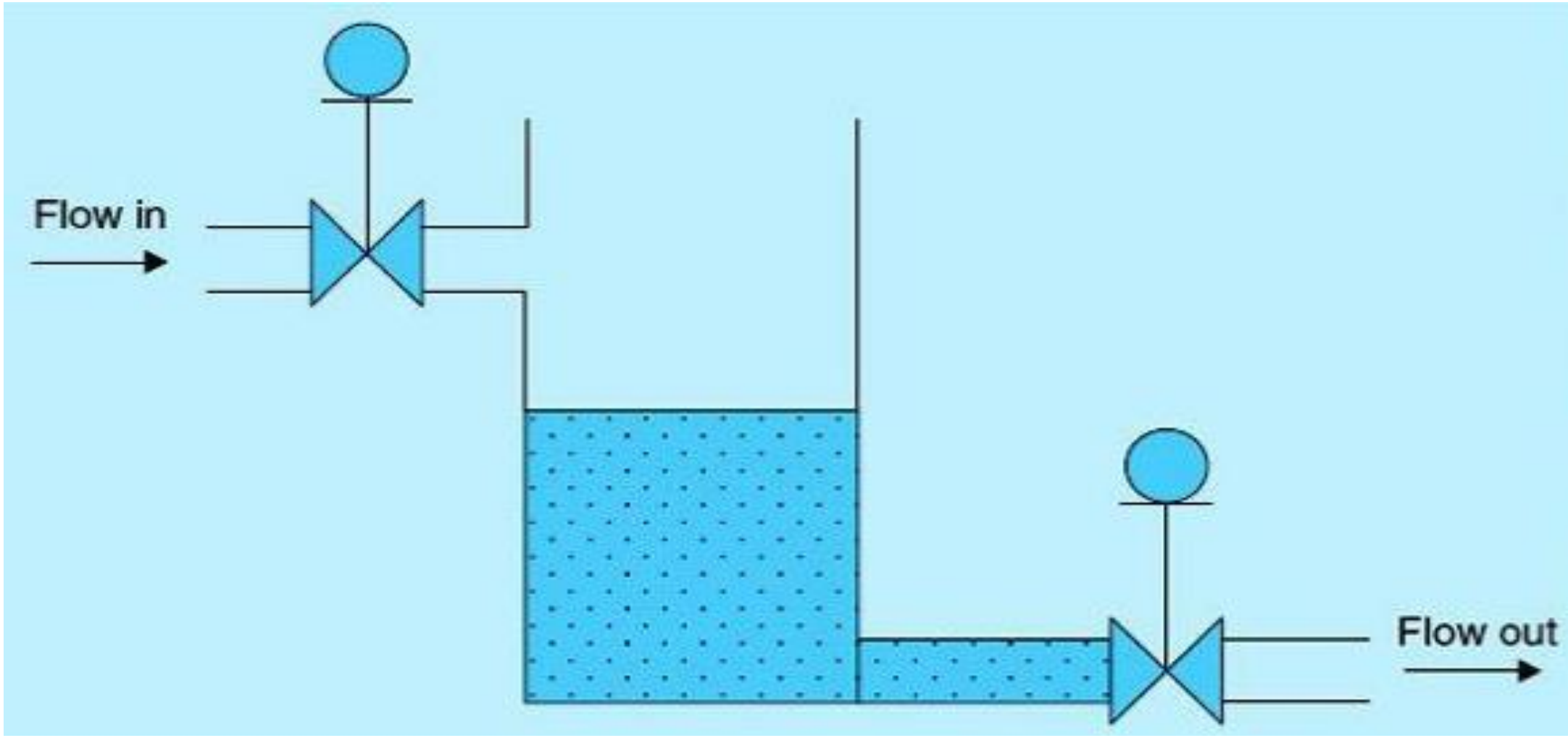
Block Diagram of CLCS



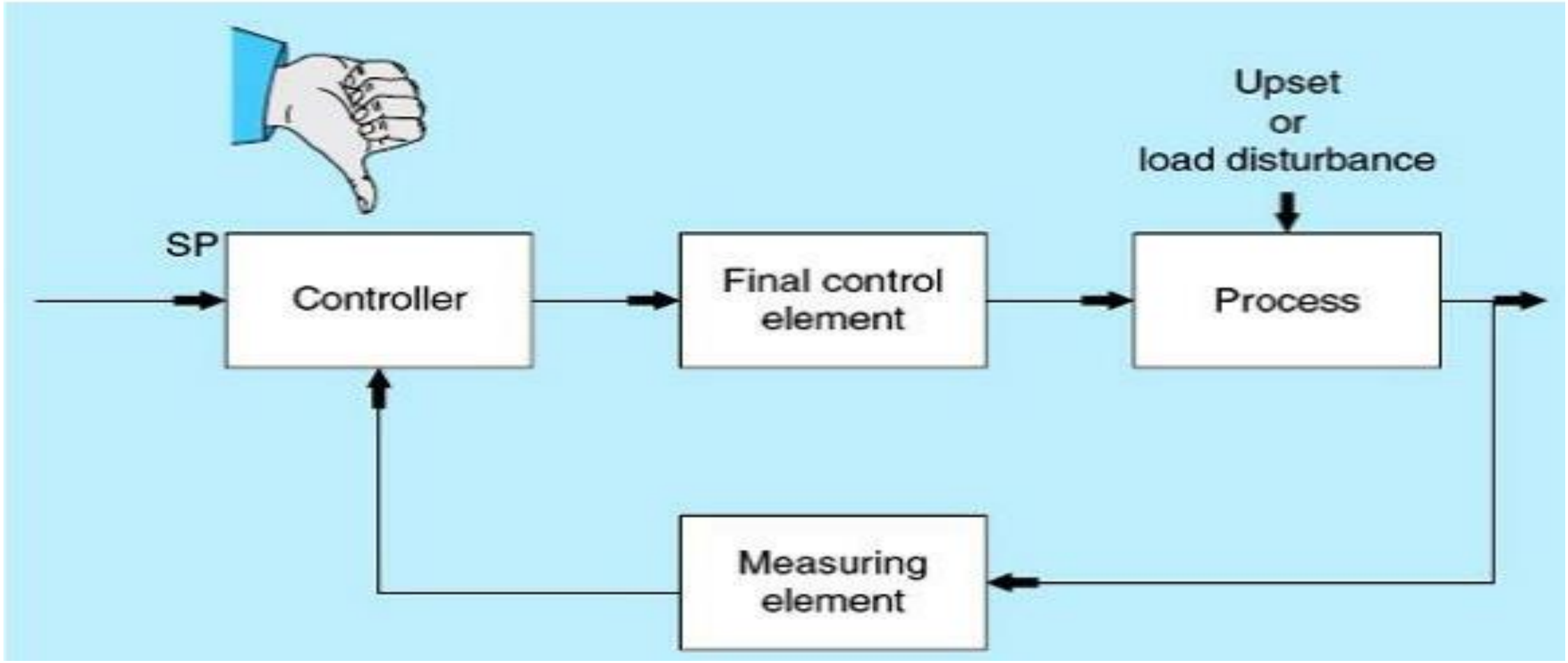
Manual Control Operation



Manual Control Operation



Automated-System Building Block



Pneumatics and control system

In the majority of applications compressed air is used for one or more of the following functions:

- ✓ To determine the status of processors (sensors)
- ✓ Information processing (processors)
- ✓ Switching of actuators by means of final control elements
- ✓ Carrying out work (actuators)

Pneumatics and control system

The factors must be considered in the control systems such as:

- ✓ Preferred control methods
- ✓ Available resources
- ✓ Available expertise
- ✓ Systems currently installed which are to be integrated with the new project

Pneumatics and control system

Criteria for a working medium	
Choice of working media:	***Selection criteria for the working section:***
✓ Electrical current (electricity) ✓ Fluids (hydraulics) ✓ Compressed air (Pneumatics) ✓ A combination of the above	✓ Force ✓ Stroke ✓ Type of motion (linear, swiveling, rotating) ✓ Speed ✓ Service life ✓ Safety and reliability ✓ Energy costs ✓ Controllability ✓ Storage

Pneumatics and control system

Criteria for a control medium	
Choice of control media:	***Selection criteria for the control section:***
✓ Mechanical connections (mechanics) ✓ Electrical current (electrics, electronics) ✓ Fluids (hydraulics) ✓ Compressed air (pneumatics, low pressure pneumatics)	✓ Reliability of components ✓ Sensitivity to environmental influences ✓ Ease of maintenance and repair ✓ Switching time of components ✓ Signal speed ✓ Space requirements ✓ Service life ✓ Modification of the control system ✓ Training requirements of operators and maintenance personnel

Pneumatics and control system

The product development in pneumatics can be considered in a number of areas:

- ✓ Actuators
- ✓ Processors
- ✓ Sensors and input devices
- ✓ Accessories
- ✓ Control systems

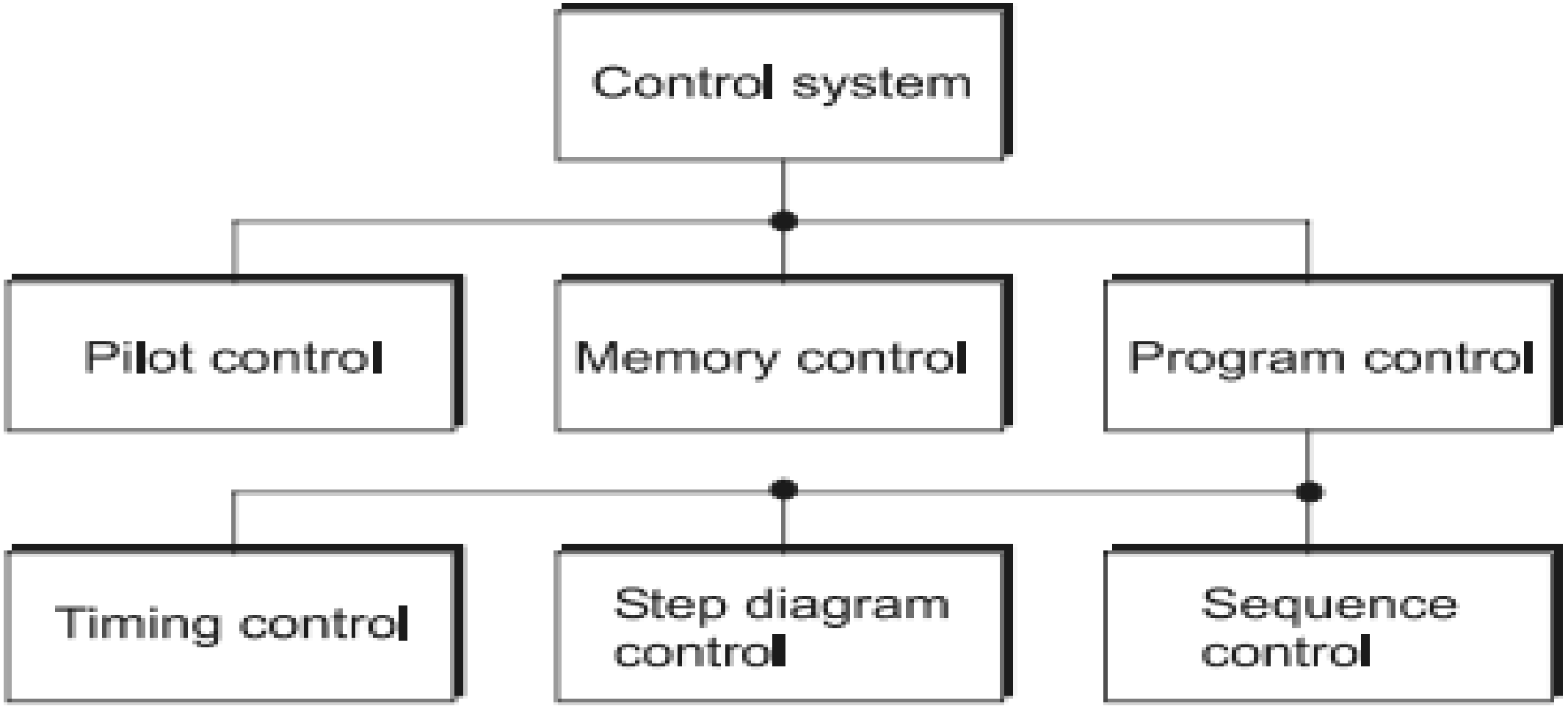
Pneumatics and control system

The following factors must be taken into account in the development of pneumatic control systems:

- ✓ Reliability
- ✓ Ease of maintenance
- ✓ Cost of spare parts
- ✓ Assembly and connection
- ✓ Maintenance and repair costs
- ✓ Interchangeability and adaptability
- ✓ Compact design
- ✓ Economic efficiency
- ✓ Documentation

Control theory

Control types according to DIN 19226



Control theory

Control types according to DIN 19226

Pilot control system

There is always a clear relationship between the command or reference value and the output value provided disturbance variables do not cause any deviations. Pilot controls do not have a memory function.

Memory control system

When the command or reference value is removed or cancelled, in particular after completion of the input signal, the output value achieved is retained (memorized). A different command value or an opposing input signal is required to return the output value to an initial value. Memory control systems always have a storage function.

Control theory

Control types according to DIN 19226

Program control

The three types of program control are:

- *Step diagram control*

In the case of step diagram control, the reference variables are supplied by a program generator (program memory), whose output variables depend on the path travelled or the position of a moving part of the controlled system.

- *Sequence control system*

The sequence program is stored in a program generator which runs through the program step-by-step according to the status attained by the system being controlled. This program may either be permanently installed or else read from punched cards, magnetic tapes or other suitable memories.

Control theory

Control types according to DIN 19226

Program control

- *Time (schedule) control*

In a time (schedule) control system, the command values are supplied by a time-dependent program generator. Characteristics of a timing control system are, thus, the existence of a program generator and a time-dependent program sequence. Program generators may be:

- Camshafts
- Cams
- Punched cards
- Punched tape
- Programs in an electronic memory

Control theory

Control system types

Differentiation between the control systems can be made on the basis of different viewpoints. According to these standard, distinguishing features for control systems are in the form of the representation of information and in the form of signal processing.

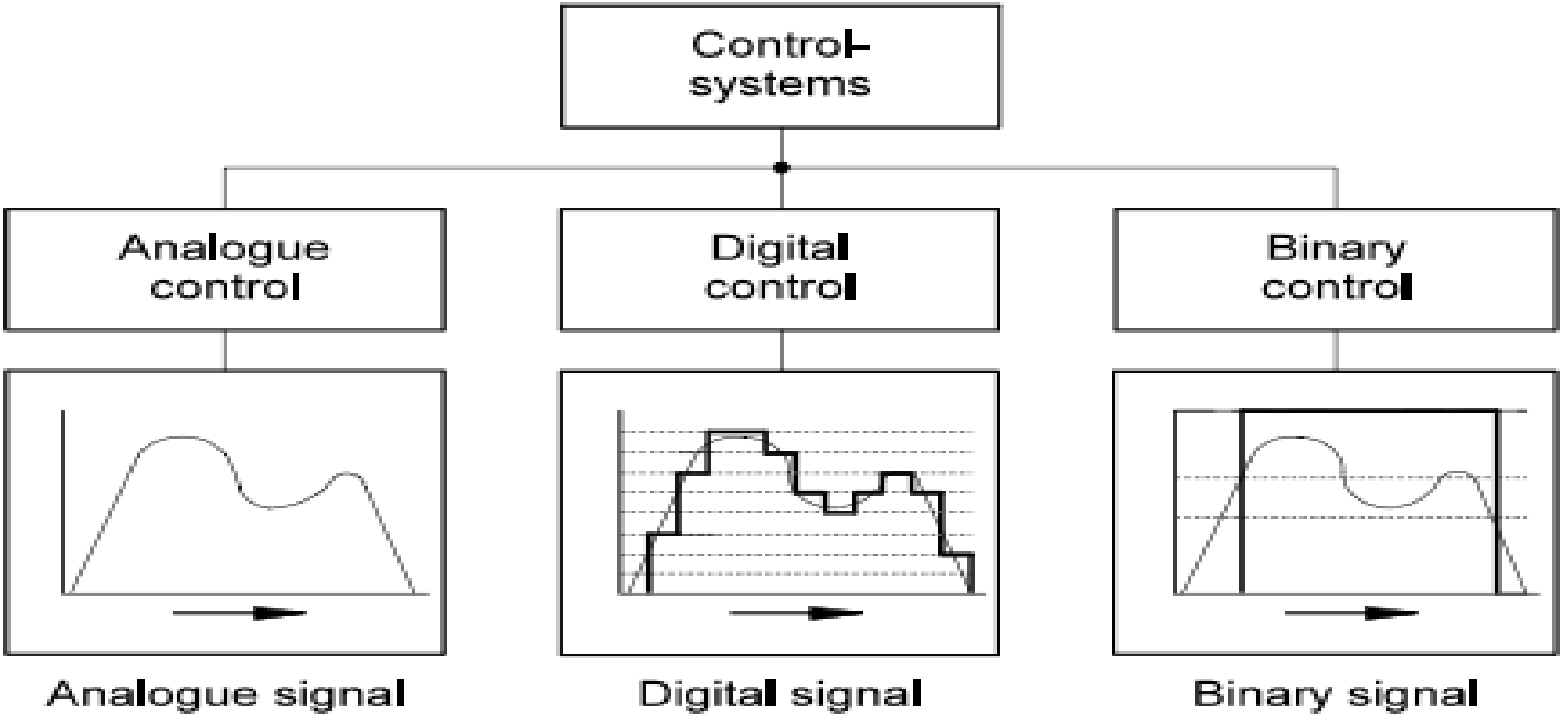
- ✓ **Form of information representation**

- ✓ **Form of signal processing**

Control theory

Control system types

Form of information representation



Control theory

Control system types

Form of information representation

Analogue control system

A control system which operates predominantly with analogue signals within the signal processing section. Signal processing is affected primarily with continuously acting function elements.

Digital control system

A control system which operates chiefly using numerical digital signals within the signal processing section. The information is represented numerically. The function units are: Counters, registers, memories, arithmetic units.

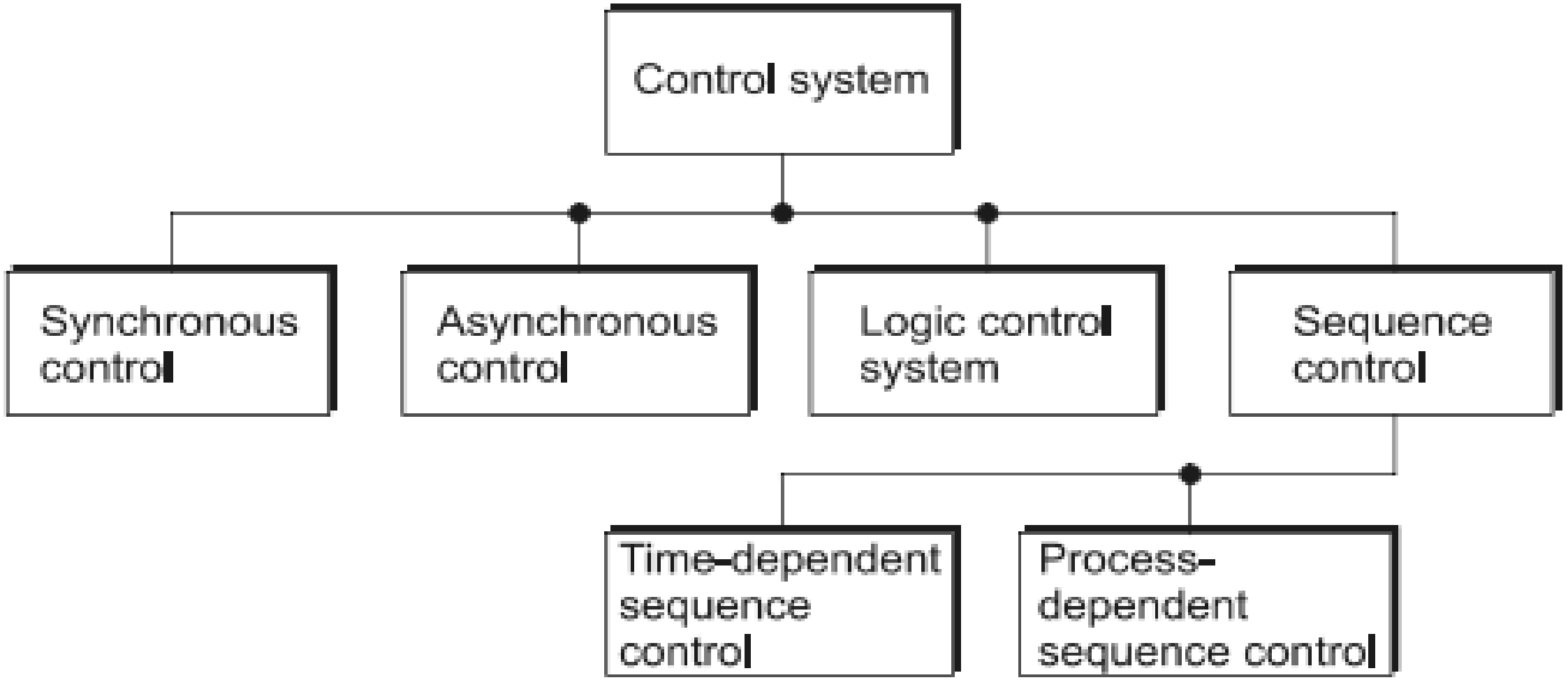
Binary control system

A control system which operates predominantly with binary signals within the signal processing section and where the signals are not part of numerically represented data.

Control theory

Control system types

Form of signal processing



Control theory

Control system types

Form of signal processing

Synchronous control system

A control system where signal processing is synchronous to a clock pulse.

Asynchronous control system

A control system operating without clock pulses where signal modifications are only triggered by a change in the input signals.

Logic control system

A control system where specific signal status for the output signals are assigned to the signal status of the input signals by means of Boolean logic connections (e.g. AND, OR, NOT).

Control theory

Control system types

Form of signal processing

Sequence control system

A control system with compulsory stepped operation where switching on from one step to the next in the program is dependent upon certain conditions being satisfied. In particular, the programming of jumps, loops, branching, etc. is possible.

Sequence control is divided into two subgroups:

Time-dependent sequence control system

A sequence control whose switching conditions are dependent only on time. Step enabling conditions are generated via timers, or camshaft controllers with constant speed. The existing term of timing control according to DIN 19226 is subject to the time-dependent specification of reference variables.

Process-dependent

A sequence control system whose switching conditions are dependent only on signals from the system being controlled. Step-diagram control as defined in DIN 19226 is a form of process-dependent sequence control, whose step enabling conditions depend purely on the stroke-dependent signals of the controlled system.

Control theory

Control system development

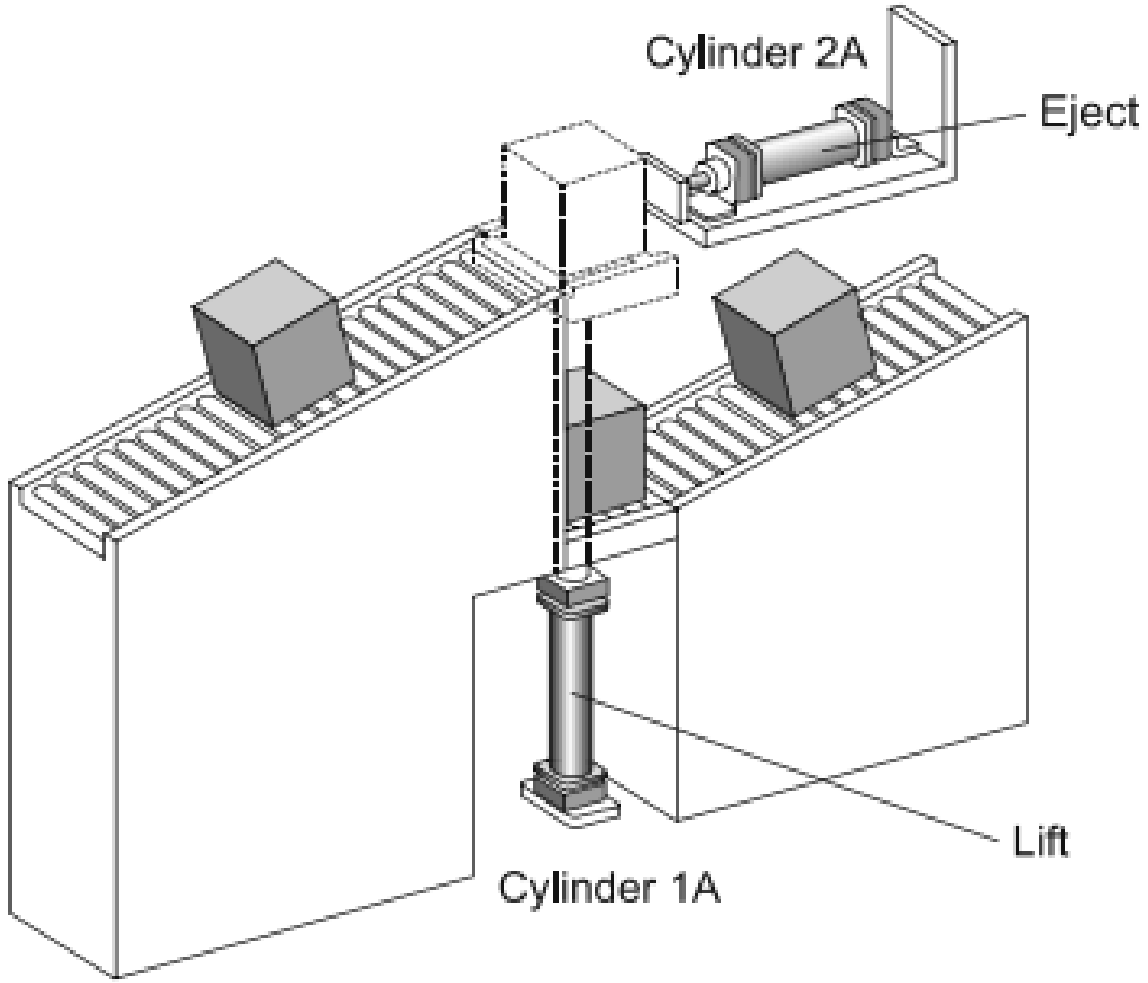
The development of the control system solution requires that the problem is defined clearly. There are many ways of representing the problem in a descriptive or graphical form. The methods of representing the control problem include:

- ✓ Positional sketch
- ✓ Displacement-step diagram
- ✓ Control chart
- ✓ Function diagram
- ✓ Function chart
- ✓ Circuit diagram

Control theory

Control system development *Positional sketch*

The positional sketch shows the relationship between the actuators and the machine fixture. The actuators are shown in the correct orientation. The positional sketch is not normally to scale and should not be too detailed. The diagram will be used in conjunction with the description of the machine operation and the motion diagrams.



Positional sketch example

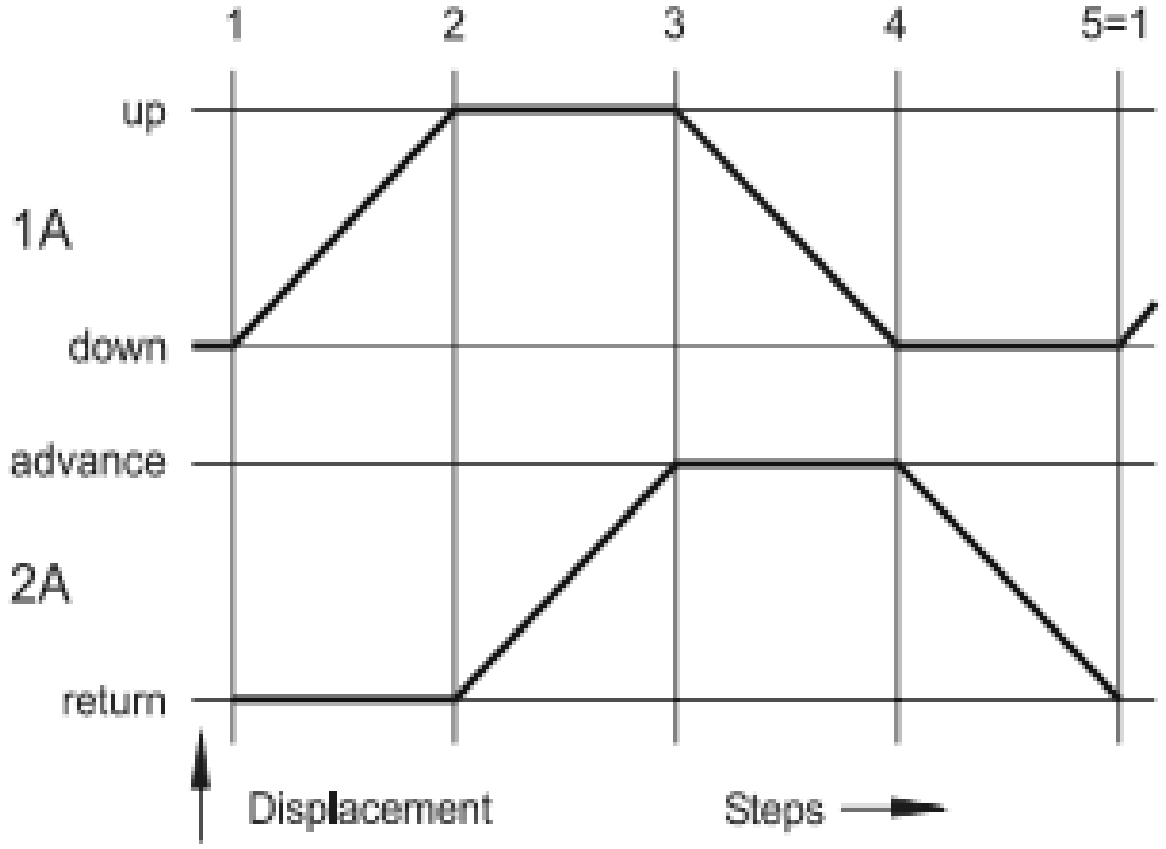
Control theory

Control system development

Displacement-step diagram

The displacement-step diagram and the displacement-time diagram are used for motion sequences. The displacement-step diagram represents the operating sequence of the actuators; the displacement is recorded in relation to the sequence step.

If a control system incorporates a number of actuators, they are shown in the same way and are drawn one below the other. Their interrelation can be seen by comparing the steps.

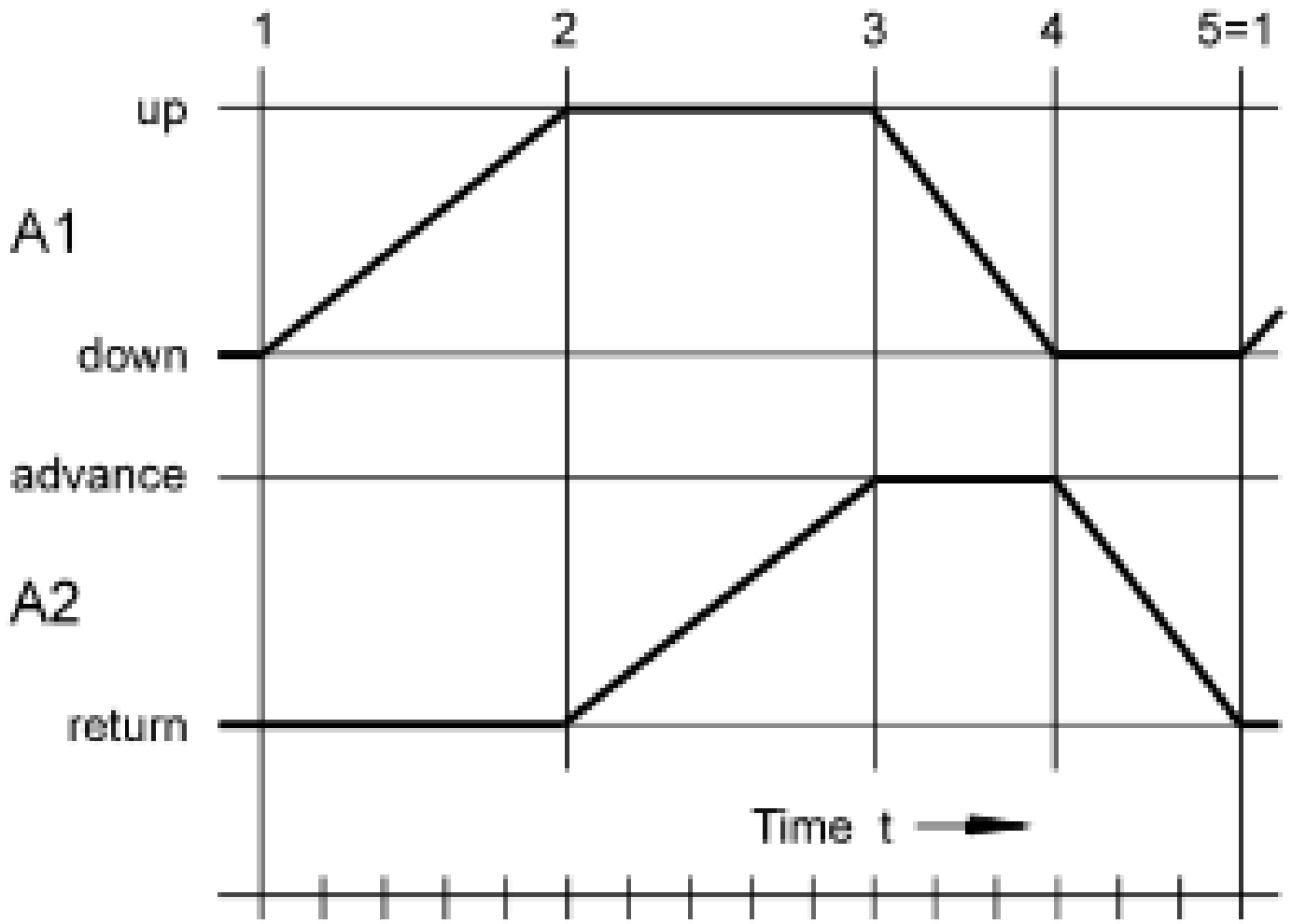


Control theory

Control system development

Displacement-time diagram

In the case of a displacement-time diagram, the displacement is plotted in relation to the time.



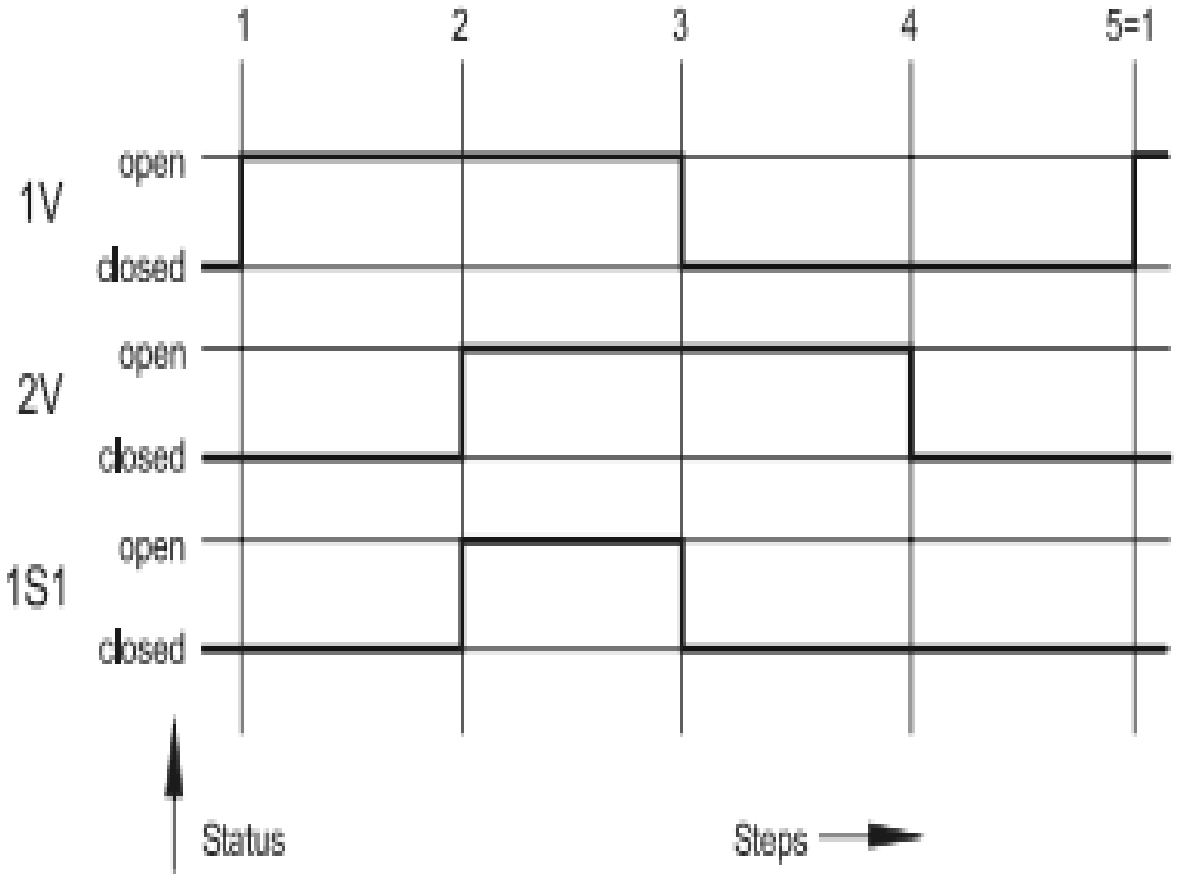
Control theory

Control system development

Control chart

In the control chart, the switching status of the control element is represented in relation to the steps or the time. The switching time is not taken into account.

The control diagram shows the statuses of the control components (1V for cylinder 1A and 2V for cy1inder 2A) and the status of the limit switch 1S1 fitted at the frontend position of the cylinder 1A.

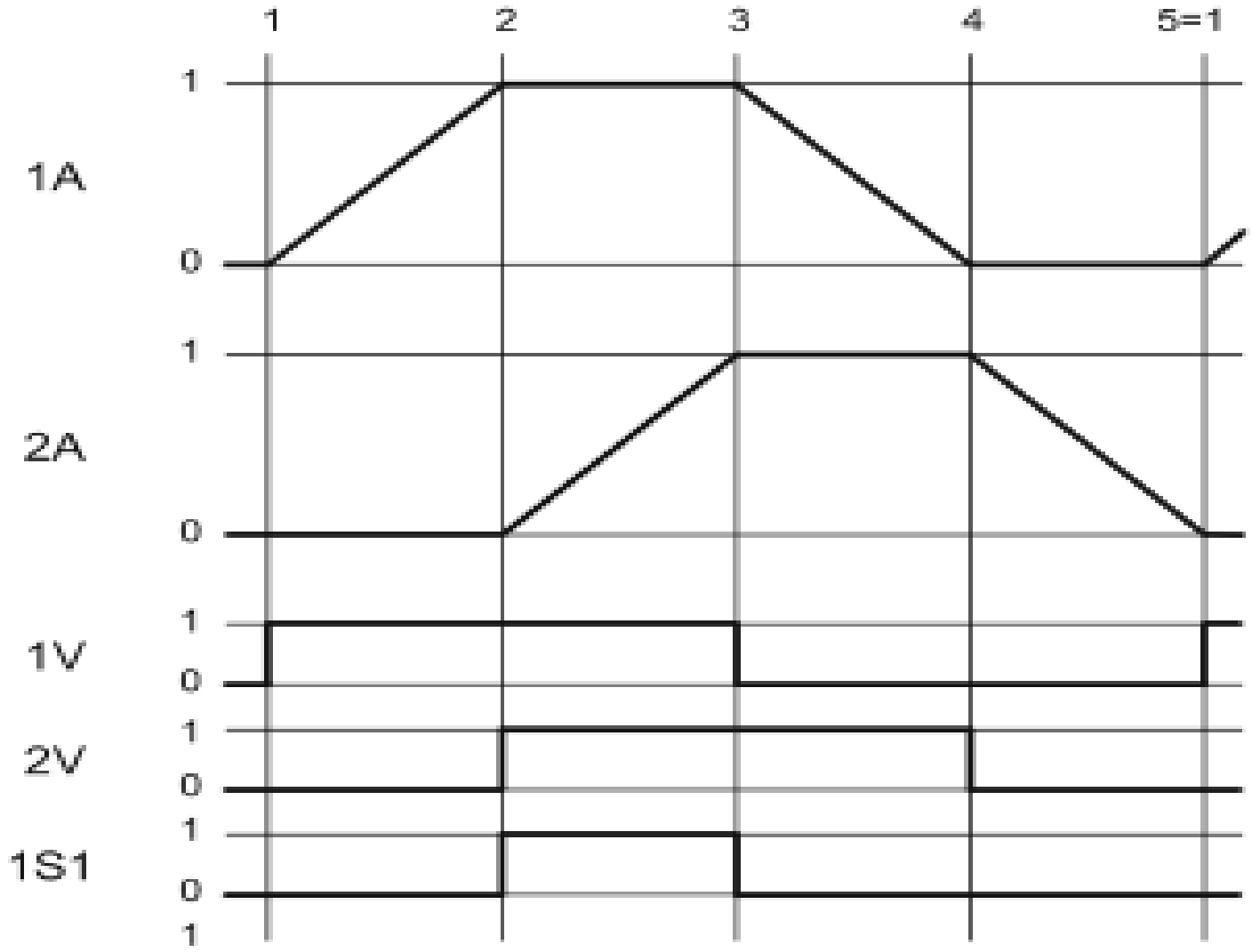


Control theory

Control system development

Function diagram

The function diagram is a combination of the motion diagram and the control chart. The lines representing the individual states are referred to as function lines

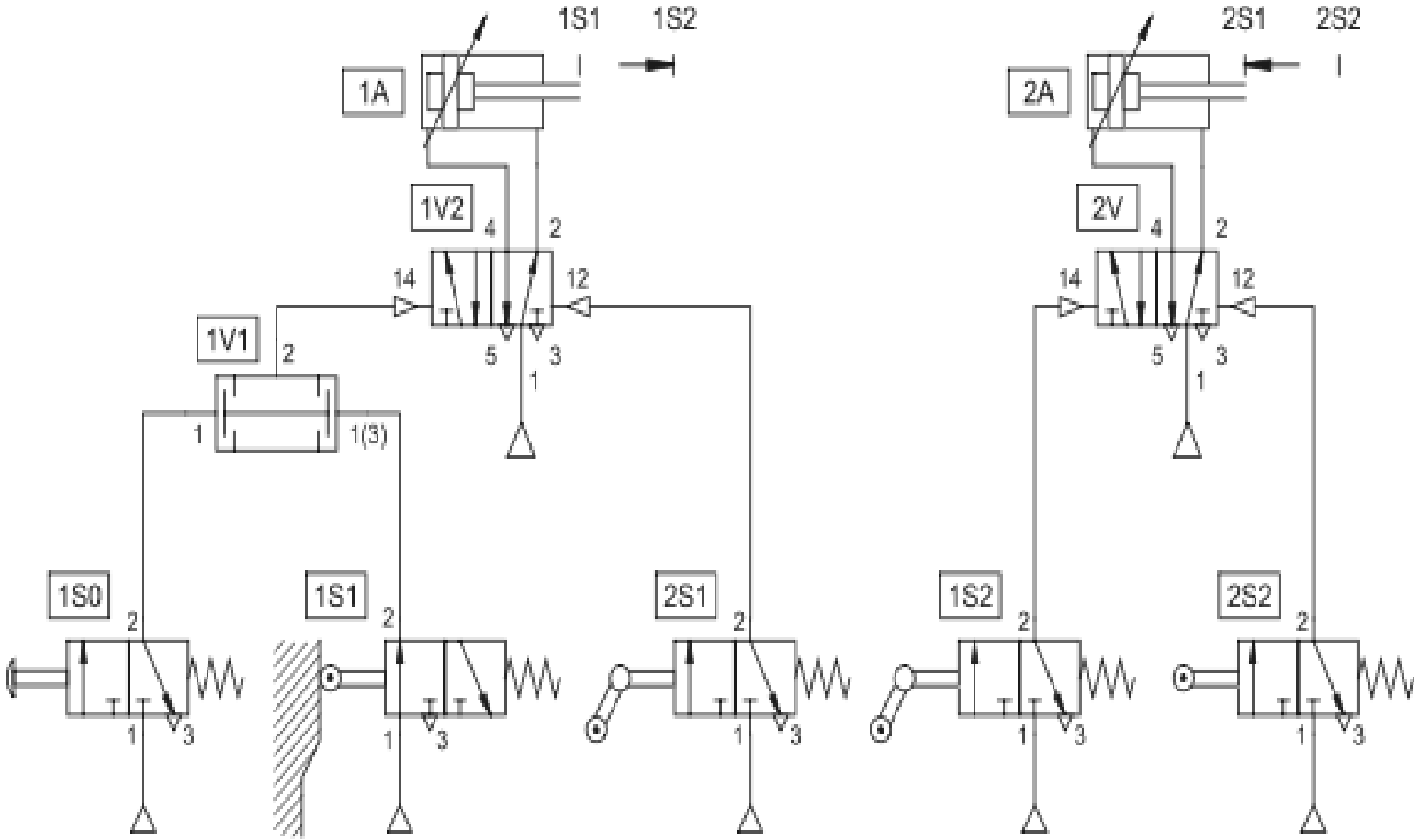


Control theory

Control system development

Circuit diagram

The circuit diagram shows signal flow and the relationship between components and the air connections. There is no mechanical layout representation with the circuit diagram.



Circuit diagram example