

Unit 11

Section One: Reading Comprehension

Introduction to Control Systems Analysis

Automatic control has played a vital role in the advance of engineering and science. In addition to its extreme importance in space-vehicle systems, missile-guidance systems, aircraft-autopiloting systems, robotic systems, and the like, automatic control has become an important and integral part of modern manufacturing and industrial processes. For example, automatic control is essential in the numerical control of machine tools in the manufacturing industries. It is also essential in such industrial operations as controlling pressure, temperature, humidity, viscosity, and flow in process industries.

In studying control engineering, we need to define those terms that are necessary to describe control systems, such as plants, disturbances, feedback control, and feedback control systems.

Plants. A plant is a piece of equipment, perhaps just a set of machine parts functioning together, the purpose of which is to perform a particular operation. In control systems, any physical object to be controlled such as a heating furnace, or a spacecraft is called a plant.

Disturbances. A disturbance is a signal that tends to adversely affect the value of the output of a system. If a disturbance is generated within the system, it is called *internal*, while an *external* disturbance is generated outside the system and is an input.

Feedback Control. Feedback control refers to an operation that, in the presence of disturbances, tends to reduce the difference between the output of a system and some reference input and that does so on the basis of this difference. Here only unpredictable disturbances are so specified, since predictable or known disturbances can always be compensated for within the system.

Feedback Control Systems. A system that maintains a prescribed relationship between the output and some reference input by comparing them and using the difference as a means of control is called a *feedback control*

system. An example would be a room-temperature control system. By measuring the actual room temperature and comparing it with the reference temperature (desired temperature), the thermostat turns the heating or cooling equipment on or off in such a way as to ensure that the room temperature remains at a comfortable level regardless of outside conditions.

Servo Systems. A servo system (or servomechanism) is a feedback control system in which the output is some mechanical position, velocity, or acceleration. Therefore, the terms servo system and position- (or velocity- or acceleration-) control system are synonymous. Servo systems are extensively used in modern industry. For example, the completely automatic operation of machine tools, together with programmed instruction, may be accomplished by the use of servo systems. It is noted that a control system, whose output (such as the position of an aircraft in space in an automatic landing system) is required to follow a prescribed path in space, is sometimes called a servo system, also. Examples include the robot-hand control system, where the robot hand must follow a prescribed path in space, and the aircraft automatic landing system, where the aircraft must follow a prescribed path in space.

Automatic Regulating Systems. An automatic regulating system is a feedback control system in which the reference input or the desired output is either constant or slowly varying with time and in which the primary task is to maintain the actual output at the desired value in the presence of disturbances. There are many examples of automatic regulating systems, some of which are the Watt's flyball governor, automatic regulation of voltage at an electric power plant in the presence of a varying electrical power load, and automatic control of the pressure and temperature of a chemical process.

Process Control Systems.

An automatic regulating system in which the output is a variable, such as temperature, pressure, flow, liquid level, or pH, is called a *process control system*. Process control is widely applied in industry. Programmed controls such as the temperature control of heating furnaces in which the furnace temperature is controlled according to a preset program are often used in such systems.

Closed-Loop Control Systems. Feedback control systems are often referred to as *closed-loop control systems*. In practice, the terms feedback control and closed-loop control are used interchangeably. In a closed-loop control system the actuating error signal, which is the difference between the input signal and the feedback signal (which may be the output signal itself or a function of the output signal and its derivatives), is fed to the controller so as to reduce the error and bring the output of the system to a desired value.