

Tutorial Questions

Problems from Chapter-1:

1.2 You are asked to design a control system to turn on lights in an art gallery at night, provided there are people inside the gallery. Explain a suitable control system, identifying the open-loop and feedback functions, if any, and describing the control system components.

1.3 Into what classification of control system components actuators, signal modification devices, controllers, and measuring devices would you put the following devices: stepper motor, proportional-plus-integration circuit, power amplifier, ADC, DAC, optical incremental encoder, process computer, FFT analyzer, DSP.

1.4 (a) Discuss possible sources of error that can make either open-loop control or feed-forward control meaningless in some applications. (b) How would you correct the situation?

1.5 Compare analog control and DDC for motion control in high-speed applications of industrial manipulators. Give some advantages and disadvantages of each control method for this application.

1.7 Consider the natural gas home heating system shown in Figure 1.7. Describe the functions of various components in the system and classify them into the functional groups: controller, actuator, sensor, and signal modification device. Explain the operation of the overall system and suggest possible improvements to obtain more stable and accurate temperature control.

1.9 A typical input variable is identified for each of the following examples of dynamic systems. Give at least one output variable for each system.

- (a) Human body: Neuroelectric pulses
- (b) Company: Information
- (c) Power plant: Fuel rate
- (d) Automobile: Steering wheel movement
- (e) Robot: Voltage to joint motor

1.10 Hierarchical control has been applied in many industries, including steel mills, oil refineries, chemical plants, glass works, and automated manufacturing. Most applications have been limited to two or three levels of hierarchy, however. The lower levels usually consist of tight servo loops, with bandwidths in the order of 1 kHz. The upper levels typically control production planning and scheduling events measured in units of days or weeks. A five-level hierarchy for a flexible manufacturing facility is as follows: The lowest level (level 1) handles servo control of robotic manipulator joints and machine tool degrees of freedom. The second level performs activities such as coordinate transformation in machine tools, which are required in generating control commands for various servo loops. The third level converts task commands into motion trajectories (of manipulator end effector, machine tool bit, etc.) expressed in world coordinates. The fourth level converts complex and general task commands into simple task commands. The top level (level 5) performs supervisory control tasks for various machine tools and material-handling devices, including coordination, scheduling, and definition of basic moves. Suppose that this facility is used as a flexible manufacturing workcell for turbine blade production. Estimate the event duration at the lowest level and the control bandwidth (in hertz) at the highest level for this type of application.

1.11 According to some observers in the process control industry, early brands of analog control hardware had a product life of about 20 years. New hardware controllers can become obsolete in a couple of years, even before their development costs are recovered. As a control instrumentation engineer responsible for developing an off-the-shelf process controller, what features would you incorporate into the controller to correct this problem to a great extent?