01. Define control system? Compare Open loop and closed loop Control system with two examples.

Sol: A Control system is an arrangement of components interconnected in such a way so as to regulate, direct (or) command itself to obtain a certain objective.

Open loop control system

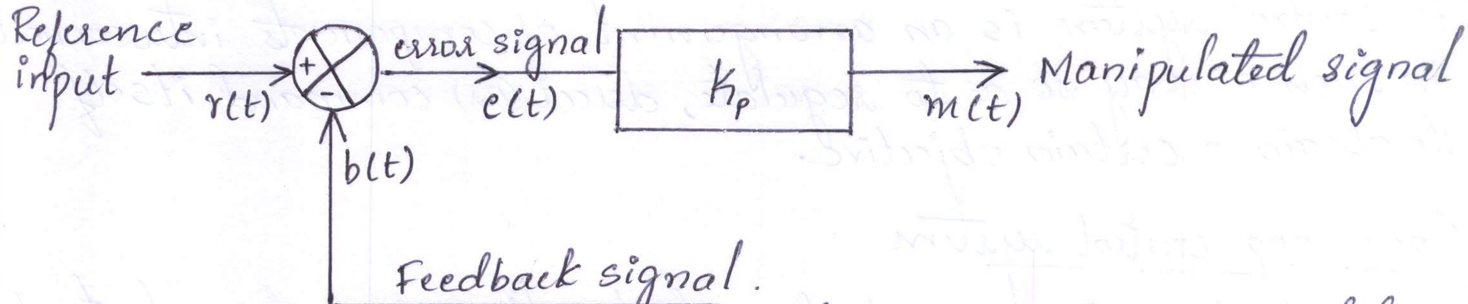
- A control system in which control action is independent of the desired output is known as Open loop control system.
- Accuracy depends on the Calibration and unreliable.
- Highly sensitive to disturbances.
- Error detector and feed back element is absent.
- The examples of an open loop control system are Traffic control system, Automatic bread toaster, Electric fan, Electric switch etc.,

Closed loop Control System

- A closed loop control system is one in which control action is dependent on the desired output.
- More accurate due to feedback and reliable.
- Less sensitive to disturbances.
- Error detector and Feed back element is Present.
- The examples of a closed loop control system are Room heating system, Automobile speed control system, Automatic tank-level system etc.,

02 Briefly explain Proportional and Integral control action with necessary block diagrams and mathematical expressions.

Sol A simple block diagram of the Proportional controller is shown in the figure. In this, the output of the controller i.e., manipulated (or) actuating signal is proportional to the input of the controller i.e, error signal.



For a controller with proportional control action the relationship between output of the controller m(t) and error signal e(t) is

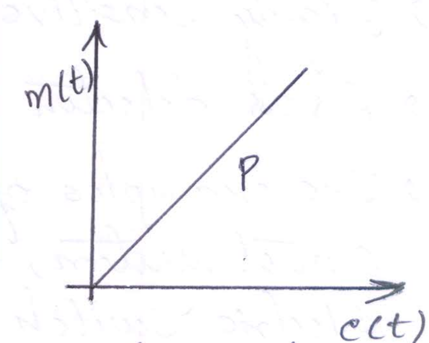
$$m(t) = K_p \, e(t)$$

Taking Laplace transform on b.s, we get.

$$M(s) = K_p \cdot E(s)$$

$$\therefore K_p = \frac{M(s)}{E(s)}$$

where, K_p = Proportional gain.



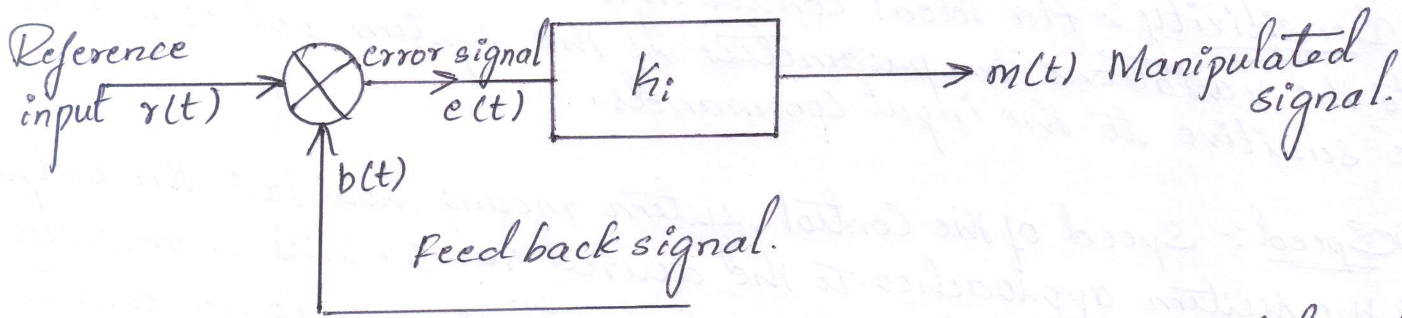
The graph shows that there exists a linear relation b/w Controller output m(t) and the error signal e(t).
For a zero error the controller output should be zero Otherwise the process will come to halt. Hence mathematically it can be expressed as

$$m(t) = K_p \, e(t) + m_0$$

where, m_0 = Controller output for zero error.

Integral-Controller

The bellow figure shows a simple block diagram of the integral controller. In this output of the controller i.e, manipulated signal is changed at a rate proportional to the input of the controller i.e, error signal.



For a controller with integral control action the relationship b/w output of the controller m(t) and error signal e(t) is

$$\frac{d\,m(t)}{dt} = k_i\, e(t)$$

By integrating, we get

$$m(t) = k_i \int e(t)\,.dt.$$

Taking Laplace transform on b.s, we get

$$M(s) = \frac{k_i}{s}\,.\,E(s)$$

$$\therefore k_i = \frac{s\,M(s)}{E(s)}$$

where, k_i = integral sensitivity $= \frac{k_p}{T_i}$

03. a. Explain the requirements of an ideal control system.

Sol (i) Stability :- Stability in a control system implies that small changes in the system input, in initial conditions (or) in system parameters do not result in large changes in the system behaviour. Stability is the important characteristic of the transient response of a control system. An ideal control system are designed to be stable.

(ii) Sensitivity :- An ideal control system should be insensitive to the variations in parameters of the system but it should be sensitive to the input commands.

(iii) Speed :- Speed of the control system means how fast the output of the system approaches to the desired value. This is measured interms of the settling time and rise time. An ideal control system should have good speed.

(iv) Accuracy :- Accuracy of the control system means how much the output of the control system is nearer to the input (or) desired value. An ideal control system must be highly accurate.

(v) Disturbance :- All control systems are subject to some type of extraneous signals (or) noise during operation. External disturbance such as wind gust, thermal noise voltage are quite common. Therefore, in the design of a control system, considerations should be given so that the system is insensitive to noise and disturbances but sensitive to input commands.

(vi) Band width :- Band width of the control system means for the range of input, the output of the control system should be constant. It refers to the frequency response of the control system. An ideal control system must give satisfactory output for the input frequency range.

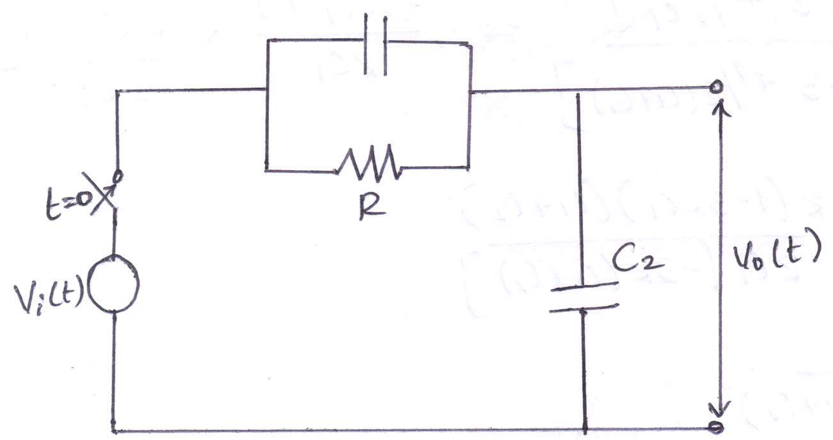
b. What is feedback? Explain the effects of feedback.

sol Feedback control system are the control system in which effect of disturbance is seen as an error after comparing the output and reference input before controller takes the proper corrective action.

Effects of feed back

- Feed back in control system improves the time response.
- By proper design and application of feedback, stability of the system can be effectively controlled.
- Gain of the system can be controlled by controlling feedback.
- Feedback in control system reduces the effect of disturbance on the system and reduces the sensitivity of the system to variation in parameter.

04. Obtain $V_o(t)$ if $C_2 = 3C_1$ and $V_i(t) = 20e^{-3t}$ and switch is closed at $t=0$.



$$Z = \frac{R/C_1 s}{R + 1/C_1 s} = \frac{R}{RC_1 s + 1}$$

$$V_i(s) = \frac{R}{RC_1 s+1} \cdot I(s) + 1/C_2 s \cdot I(s)$$

$$V_i(s) = I(s)\left[\frac{R}{RC_1 s+1} + \frac{1}{C_2 s}\right]$$

$$V_0(s) = \frac{1}{C_2 s} \cdot I(s)$$

$$T(s) = \frac{V_0(s)}{V_i(s)} = \frac{I(s)/C_2 s}{I(s)\left[\frac{R}{RC_1 s+1} + \frac{1}{C_2 s}\right]} = \frac{RC_1 s+1}{s[R(C_1+C_2)]+1}$$

$$V_i(t) = 20e^{-3t}$$

$$V_i(s) = \frac{20}{s+3}$$

$$V_0(s) = \frac{20}{s+3}\left[\frac{RC_1 s+1}{s[R(C_1+C_2)]+1}\right] = \frac{20RC_1}{R(C_1+C_2)}\left[\frac{s+1/RC_1}{(s+3)\left(s+\frac{1}{R(C_1+C_2)}\right)}\right]$$

$$\frac{s+1/RC_1}{(s+3)(s+1/R(C_1+C_2))} = \left[\frac{A}{(s+3)} + \frac{B}{s+\frac{1}{R(C_1+C_2)}}\right]$$

$$s+1/RC_1 = A\left[s+\frac{1}{R(C_1+C_2)}\right] + B(s+3)$$

put $s=-3$

$$-3+1/RC_1 = A\left[-3+\frac{1}{R(C_1+C_2)}\right] + B(0)$$

$$A = \frac{(-3+1/RC_1)}{[-3+1/R(C_1+C_2)]} = \frac{-3RC_1+1}{RC_1} \times \frac{R(C_1+C_2)}{-3R(C_1+C_2)+1}$$

$$A = \frac{R(1-3RC_1)(C_1+C_2)}{RC_1[-3R(C_1+C_2)]}$$

put $s = \frac{-1}{R(C_1+C_2)}$

$$\frac{-1}{R(C_1+C_2)} + \frac{1}{RC_1} = A(0) + B\left[\frac{-1}{R(C_1+C_2)} + 3\right]$$

$$\frac{-RC_1+RC_1+RC_2}{RC_1(R(C_1+C_2))} = B\left[\frac{-1+3R(C_1+C_2)}{R(C_1+C_2)}\right]$$

$$\frac{C_2}{C_1} = B\left[-1 + 3R(C_1+C_2)\right]$$

$$3 = B\left[-1 + 3R(C_1+C_2)\right]$$

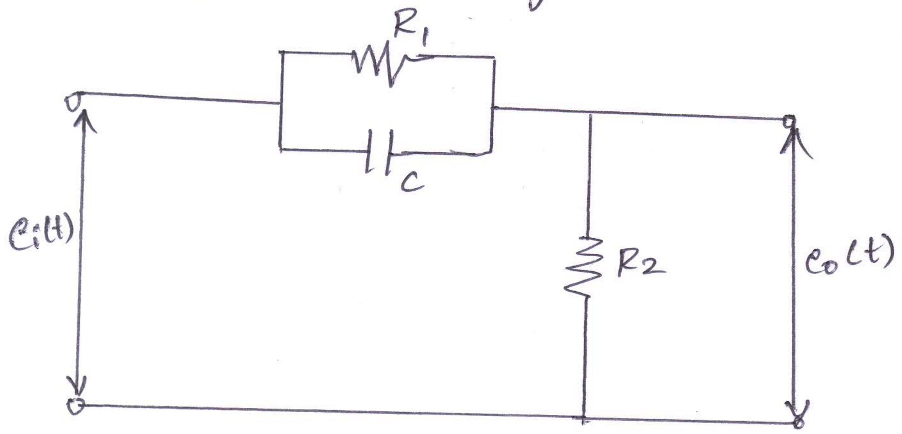
$$B = \left[\frac{3}{-1+3R(C_1+C_2)}\right]$$

$$V_o(s) = \frac{20RC_1}{R(C_1+C_2)}\left[\frac{R(1-3RC_1)(C_1+C_2)}{RC_1(-3R(C_1+C_2))}\times\frac{1}{(s+3)} + \frac{3}{-1+3R(C_1+C_2)}\times\frac{1}{s+\frac{1}{R(C_1+C_2)}}\right]$$

$$V_o(s) = \frac{20\times C_1}{\not{3\times}4C_1}\left[\frac{R(1-3RC_1)(4C_1)}{RC_1(-3R(4C_1))}\times\frac{1}{s+3} + \frac{3}{-1+12RC_1}\times\frac{1}{s+\frac{1}{4RC_1}}\right]$$

$$V_o(s) = 5\left[\frac{(1-3RC_1)(4C_1)}{C_1(-12RC_1)}\times\frac{1}{s+3} + \frac{3}{12RC_1-1}\times\frac{4RC_1}{4sRC_1+1}\right]$$

05 Find the transfer function for the given network.



Sol

$$Z = \frac{R_1\times 1/Cs}{R_1+1/Cs} = \frac{R_1}{1+sR_1C}.$$

$$e_i(s) = \frac{R_1}{1+sR_1C}\cdot I(s) + R_2\, I(s)$$

$$e_i(s) = I(s)\left[\frac{R_1}{1+sR_1C} + R_2\right]$$

$$e_o(s) = R_2\cdot I(s)$$

$$T(s) = \frac{e_o(s)}{e_i(s)} = \frac{R_2 \cdot I(s)}{I(s)\left[\frac{R_1}{1+sR_1C} + R_2\right]}$$

$$T(s) = \frac{R_2}{\frac{R_1}{1+sR_1C} + R_2}.$$

laplace transform of the network.