JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING
EEE2507 CONTROL ENGINEERING IV
ISSUED: 09/10/2024   DUE 25/11/2024

INSRUCTIONS

1. *Do the assignments in Groups of 8 to10 (Same as for labs), type and email soft copies in word format to laloo@jkuat.ac.ke on or before the due date.*
2. *Show how the workload has been shared.*
3. *Marks will be lost for resembling/copied work.*

ASSIGNMENT I

QUESTION ONE: PID CONTROLLER

a) Given the PD controller in Fig. Q1a) (ii), determine the values of R_2 and C for proportional and derivative gains of $K_P = 8$, $K_D = 12$ given that $R_1 = R_3 = 5k, R_2 = R_4$.

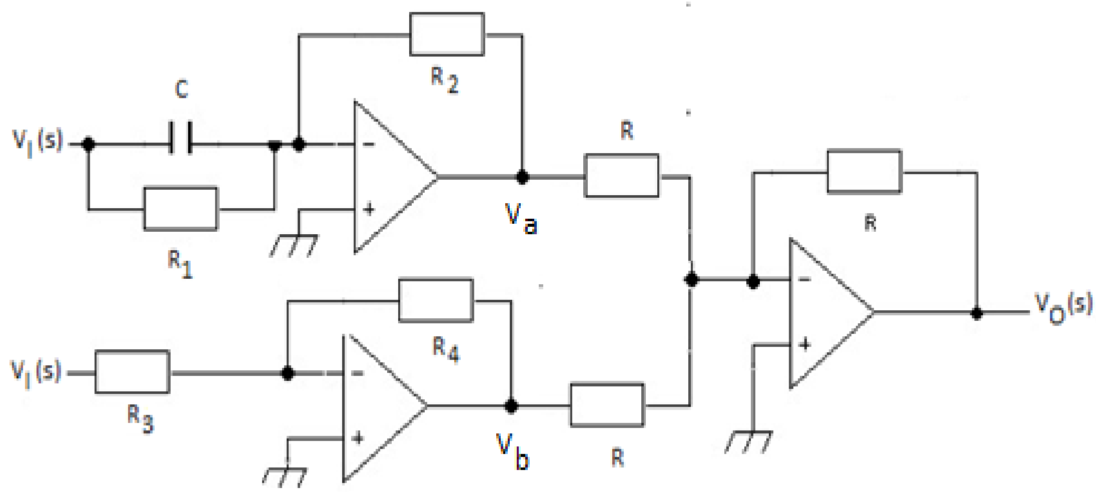

Fig. Q1a)

b) Fig. Q1 shows an electronic PID controller with the following specifications:

I. Proportional gain, $K_p = 5$;
II. Integral gain, $K_i = 0.1$;
III. Derivative gain, $K_d = 0.6$;
IV. Derivative coefficient, $\alpha = 0.1$;
V. Capacitor, $C_2 = 10\mu F$.

Determine the values of:

i. Resistor R_2;
ii. Resistor R_1;
iii. Resistor R_3;
iv. Capacitor, C_1

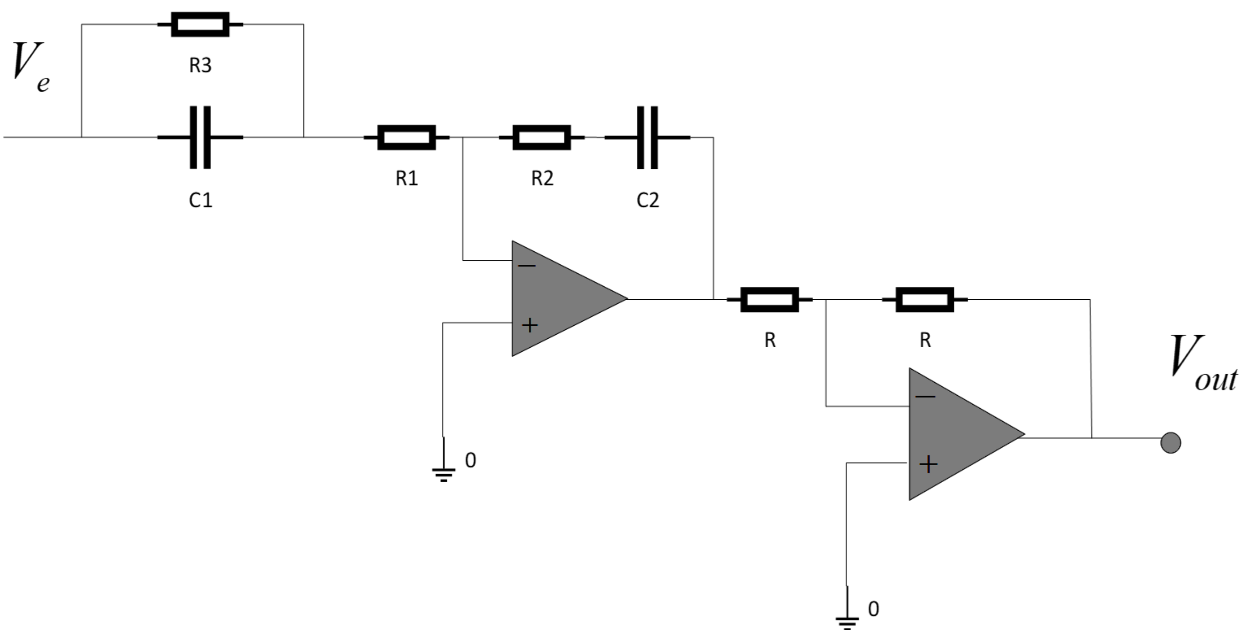

Fig. Q1b) shows an electronic PID controller

QUESTION TWO: NON-LINEAR CONTROL

Consider the 3-position relay with hysteresis nonlinearity shown in Fig. Q2:

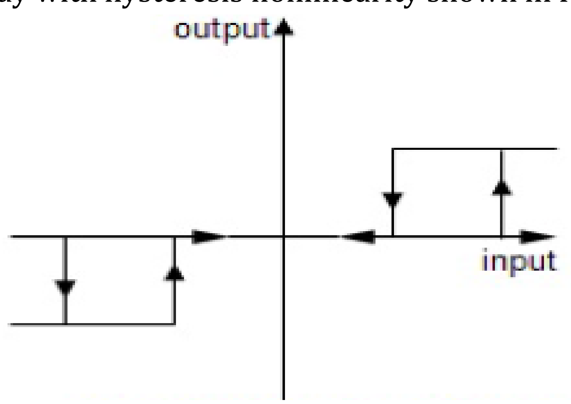

Fig. Q2

a) Obtain the describing function for the nonlinearity shown in Fig. Q2.

b) Using **MATLAB**, simulate the nonlinearity shown in Fig. Q2 and obtain the resultant output.

c) Compare a) and b) above.

QUESTION THREE: NON-LINEAR CONTROL

Obtain the describing function for the nonlinearity shown in Fig Q3.

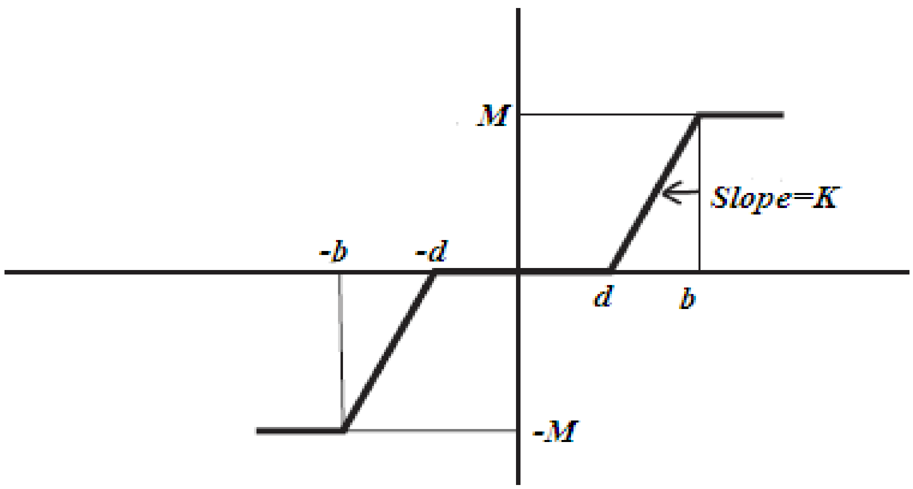

Fig Q3

a) Obtain the describing function for the nonlinearity shown in Fig. Q3.

b) Using **MATLAB**, simulate the nonlinearity shown in Fig. Q3 and obtain the resultant output.

c) Compare a) and b) above.

QUESTION THREE: OPTIMAL CONTROL

Minimize, using the Hamiltonian Approach, the cost function

$$J = \int_0^2 \frac{1}{2} u^2(t)\ dt$$

Given the system under control is

$$\begin{bmatrix} \dot{x}_1(t) \\ \dot{x}_2(t) \end{bmatrix} = \begin{bmatrix} 0 & 2 \\ 2.5 & 1 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t)$$

Subject to boundary conditions

$$\begin{bmatrix} x_1(0) \\ x_2(0) \end{bmatrix} = \begin{bmatrix} -2 \\ 1 \end{bmatrix} \ and \ \begin{bmatrix} x_1(2) \\ x_2(2) \end{bmatrix} = \begin{bmatrix} 4 \\ -1 \end{bmatrix}$$

Confirm your solution using the Lagrange Multiplier method,

ASSIGNMENT II

QUESTION ONE: OPTIMAL CONTROL

a) Outline the procedure for designing a Linear Quadratic Tracking System.

b) A second order plant

$$\dot{x}_1(t) = 3x_2(t),$$

$$\dot{x}_2(t) = -3x_1(t) + 2x_2(t) + 1.2u(t)$$

$$y(t) = x(t)$$

is to be controlled to minimize the performance index

$$J = [2.5 - x_1(t_f)]^2 + \int_{t_0}^{t_f} [[2.5 - x_1(t)]^2 + 0.6u^2(t)]dt$$

The final time t_f is specified at 15, the final state $x(t_f)$ is free and the admissible controls and states are unbounded. It is required to keep the state $x_1(t)$ close to 1.

i. Using the Riccati Equation, Obtain the feedback control law.

ii. **Repeat Using MATLAB** and plot all the time histories of Riccati coefficients, g vector components, optimal states, and control.

QUESTION TWO: DIGITAL CONTROL

a) Given the system

$$x(k+1) = \begin{bmatrix} 4.1 & 1.2 \\ 1.6 & 2.2 \end{bmatrix} x(k) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(k)$$

$$y(k) = \begin{bmatrix} 0 & 1 \end{bmatrix} x(k)$$

i. Determine a linear state-feedback controller $u(k) = -Lx(k)$ such that the closed loop poles are $3.5 \pm j0.8$.

ii. Design a suitable full-order state observer such that the system will have closed loop poles at $1.5 \pm j0.6$.

iii. Verify your solutions using MATLAB.

QUESTION THREE: DIGITAL CONTROL

Fig. Q3 Ass II shows a digital control system. The open-loop transfer function is given by:

When the controller gain K is 2 and the sampling time is 0.25 seconds, determine:

i. the open loop pulse transfer function

ii. the closed loop pulse transfer function

iii. the difference equation for the discrete time response

iv. the stability of the system

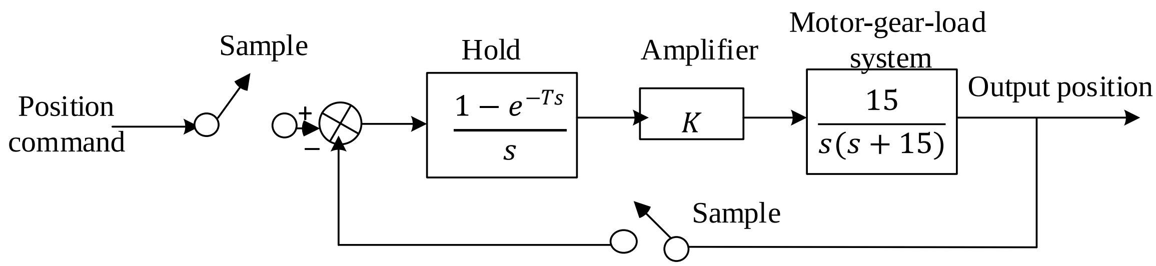

Fig. Q3 Ass II A digital control system

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