VIT
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

Vellore – 632014, Tamil Nadu, India

SCHOOL OF ELECTRICAL ENGINEERING

FALL SEMESTER 2023-2024

CAT-II

SLOT: G1+TG1

Programme Name & Branch	:	B.Tech & EEE/EIE
Course Code	:	BEEE303L
Course Name	:	Control Systems
Faculty Members	:	Dr Dhanamjayulu C Dr. V. Bagyaveereswaran Dr. V. Gayathri
Class Number(s)	:	VL2023240102937/ VL2023240102935/ VL2023240103331
Date of the Examination	:	21.10.2023

Duration : 90 minutes **Max. Marks : 50**

General instruction(s): Use

Answer all the Questions (5 x 10 = 50 Marks)

Q. No	Question	Marks	CO	BL
1.	The overall transfer function of a unity feedback system is given by $\frac{C(s)}{R(s)} = \frac{10}{(s^2+6s+10)}$. Determine (i) Type number of the system (ii) Error constants (iii) Steady state error for the input $r(t) = 1 + t + t^2$.	10	CO2	BL6
2.	For the unity feedback system whose open loop transfer function is $G(s) = \frac{k}{s(s+1)(s+2)(s+5)}$. (i) Find the range of k for stability (ii) Find the value of k for marginally stable (iii) Find the actual location of the closed loop poles when the system is marginally stable using Routh Hurwitz criterion.	10	CO3	BL4
3.	Test the stability of a system whose characteristics equation is $s^5 + 2s^4 + 2s^3 + 4s^2 + s + 2 = 0$. How many roots of the characteristics equation are in the right half plane, the left half plane and on the $j\omega$ – axis.	10	CO3	BL3

4.	The open loop transfer function of a control system is given by $G(s)H(s) = \frac{k}{s(s+6)(s^2+4s+13)}$. Sketch the root locus plot and determine (i) The breakaway points (ii) The angle of departure from complex poles (iii) The stability condition	10	CO3	BL5
5.	The open loop transfer function of an unity feedback system is given by $G(s) = \frac{k}{s(1+0.02s)(1+0.04s)}$. Draw the Bode plot. Find the gain margin and phase margin. Hence find the value of open loop gain so that the system has a phase margin of 45°.	10	CO3	BL3

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Q. No	Key points

1. Open loop transfer function G(s) = 10/s(s+6)

   Type no. = one

   Error constants: Kp = Infinity , Kv = 1.67 and Ka = zero

   Steady state error = infinity

2. Chars. Eqn. is s^4 + 8s^3 + 17s^2 + 10s + k = 0

   (157.5 – 8k)/15.75 > 0 and k < 19.6875

   Range of K : 0 < k < 19.6875

   Auxiliary equation is 15.75s^2 + 19.6875 = 0

   Roots are ± j1.118

   Other two roots are -4.5 and -3.5

3. 1st Auxiliary polynomial A(s) is 2s^4 + 4s^2 + 2 = 0

   dA/ds = s^3 + s = 0

   2nd Auxiliary polynomial

   A(s) is s^2 + 1 = 0

   dA/ds = 2s + 0 = 0

s^5	1	2	1
s^4	2	4	2
s^3	1	1	
s^2	1	1	
s	2		
s^0	1		

There is no sign change in the first column

From 1st auxiliary equation, roots are j, -j, j, -j. Four roots are lying on jω axis. Remaining one root is in the LHS of s-plane. Here repeated roots are on the imaginary axis. **Hence the system is unstable.**

4. The open loop transfer function of a control system is given by

$$G(s)H(s) = \frac{k}{s(s+6)(s^2+4s+13)}.$$

Poles are 0, -6 and -2 ± j3

Angle of asymptotes: 45, 135, 225, 315 deg

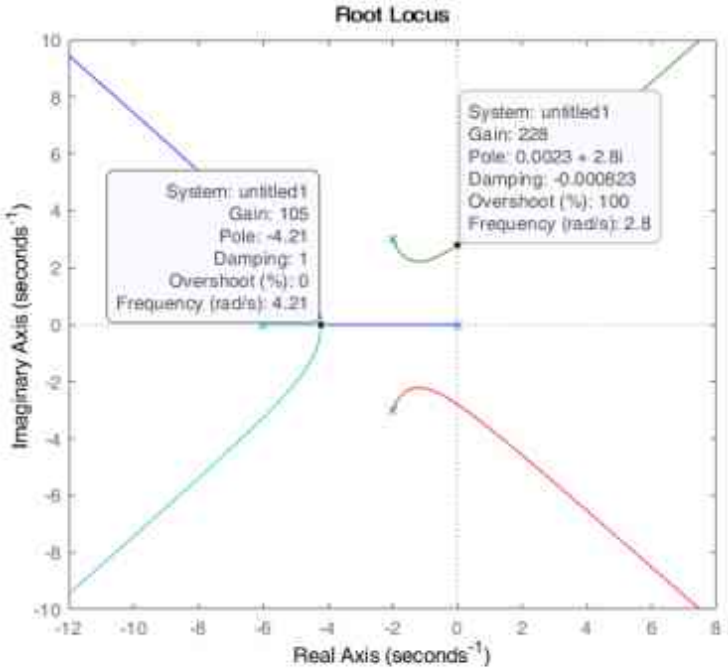
Centroid point = -2.5

(i) Break Away point:
dk/ds = 0
roots are -4.2 and -1.65 ± j1.386
so, breakaway point = -4.2

- Crossing point on the imaginary axis = ± j 2.79

(ii) The angle of departure from complex poles = 180 – (17.672 + 90 + 139.96) = - 67.632

(iii) The stability condition, k: 0 < k < 227.8



5. The open loop transfer function of a unity feedback system is given by

$G(s) = \dfrac{k}{s(1+0.02s)(1+0.04s)}$. Draw the Bode plot. Find the gain margin and phase margin.

Hence find the value of open loop gain so that the system has a phase margin of 45°.

Magnitude plot:

Corner frequencies: ωc1 = 25 rad/sec and ωc2 = 50 rad/sec

Gain in db at 1 rad/sec = 0 db

Gain in db at 25 rad/sec = -28 db

Gain in db at 50 rad/sec = -40 db

Gain in db at 500 rad/sec = -100 db

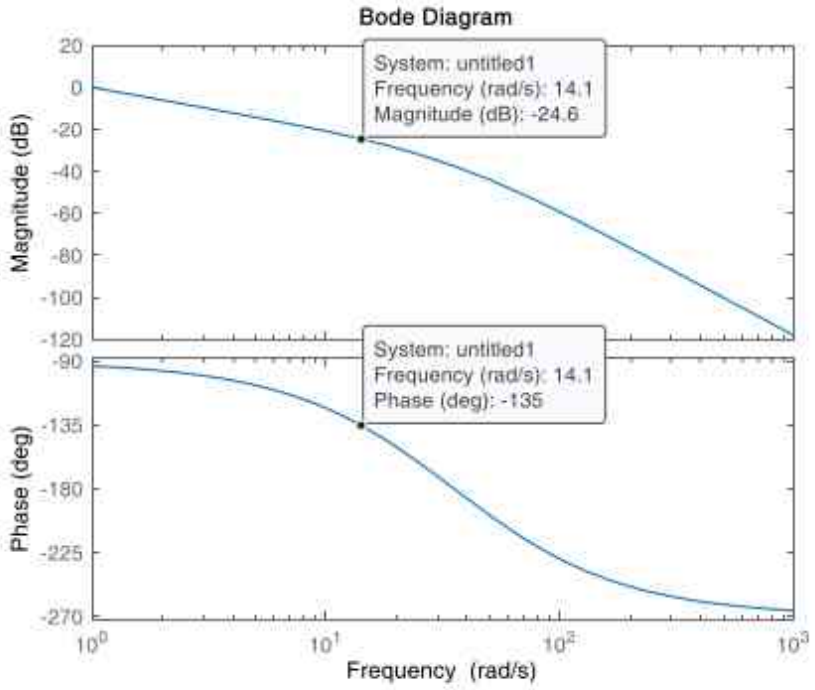
Phase plot:

ϕ in deg = $-90 - \tan^{-1}(0.02\omega) - \tan^{-1}(0.04\omega)$

ω	0	0.1	1	10	20	100
ϕ in deg	-90	-90.34	-93.4	-123	-150	-230

Given phase margin = 45°

$\phi gc = 45° - 180° = -135$ deg



Gain to be added at every point = 24 db

20 x log K = 24; k = 10 ^(24/20) = 15.85