Eskişehir Osmangazi University - Electrical Engineering Department Fundamentals of Control Systems; 2nd Midterm Examination - Spring 2012

For each question, put the answer just next to or below it. Correct answers are sufficient for full credits.

1. [20 pts.] Pole/zero locations for various LTI systems are as follows:

System No.	Poles	Zeros
1	$\{-2, -1+3i, -1-3i\}$	$\{1, -1\}$
2	$\{-2, -1, -1, -1 + 2i, -1 - 2i\}$	$\{-1, -2 - i, -2 + i\}$
3	$\{-2, -1, 0, -6\}$	$\{1, 1, -2\}$
4	$\{-2, -1, 1\}$	$\{-1, -2, -4\}$
5	$\{-2, -1, 1\}$	$\{-6, -3, -2, -1\}$

Write the ones that are BIBO stable. 1,2 Write the ones that are minimum phase. 2 Write the ones that are strictly proper. 1,2,3 Write the ones that are proper. 1,2,3,4 2. [20 pts.] Form the Routh table for $s^4 + 6s^3 + 2s^2 + 4s + 6 = 0$. How many roots are in open left half plane?

```
Routh Table
```

s⁴ [1, 2, 6] s³ [6, 4, 0] s² [4/3, 6, 0] s¹ [-23, 0, 0] s⁰ [6, 0, 0]

Two roots are in the OLHP. Indeed the roots are: $-5.74, -0.92, 0.33 \pm i1.01$ **3.** [30 pts.] For Configuration 1, $G(s) = \frac{K(s-1)}{(s+1)(s+2+i)(s+2-i)}$ is given. Sketch the root locus. If exist(s), show values of the asymptotes, crossing points, break away points. For which K values is the closed loop system stable?



Closed loop system becomes unstable when the red trajectory crosses into the RHP. It happens at s=0. Let us use the magnitude condition at this point: $\left|\frac{K(0-1)}{(0+1)(0+2+i)(0+2-i)}\right| = 1 \rightarrow K = 5$. Thus, for K between 0 and 5 the system is stable.



4. [30 pts.] For Configuration 2, $G(s) = \frac{(2s+2)}{(s+1)(s+5)}$ and $x(t) = 3\sin(4t)$ are given. Find the steady state output $y_{ss}(t)$. Evaluate $y_{ss}(20)$.



$$|G(i4)| = \left|\frac{8i+2}{(4i+1)(4i+5)}\right| = 0.3123$$

$$\underline{/G(i4)} = \underline{/(8i+2)} - \underline{/(4i+1)} - \underline{/(4i+5)} = -0.6747 \text{ radians.}$$

$$y_{ss} = 0.3123 \times 3\sin(4t - 0.6747) = 0.9369\sin(4t - 0.6747)$$

$$y_{ss}(20) = 0.9369\sin(4 \times 20 - 0.6747) = 0.9369\sin(79.3253) = -0.6625$$

Good Luck,

A. Karamancı
oğlu