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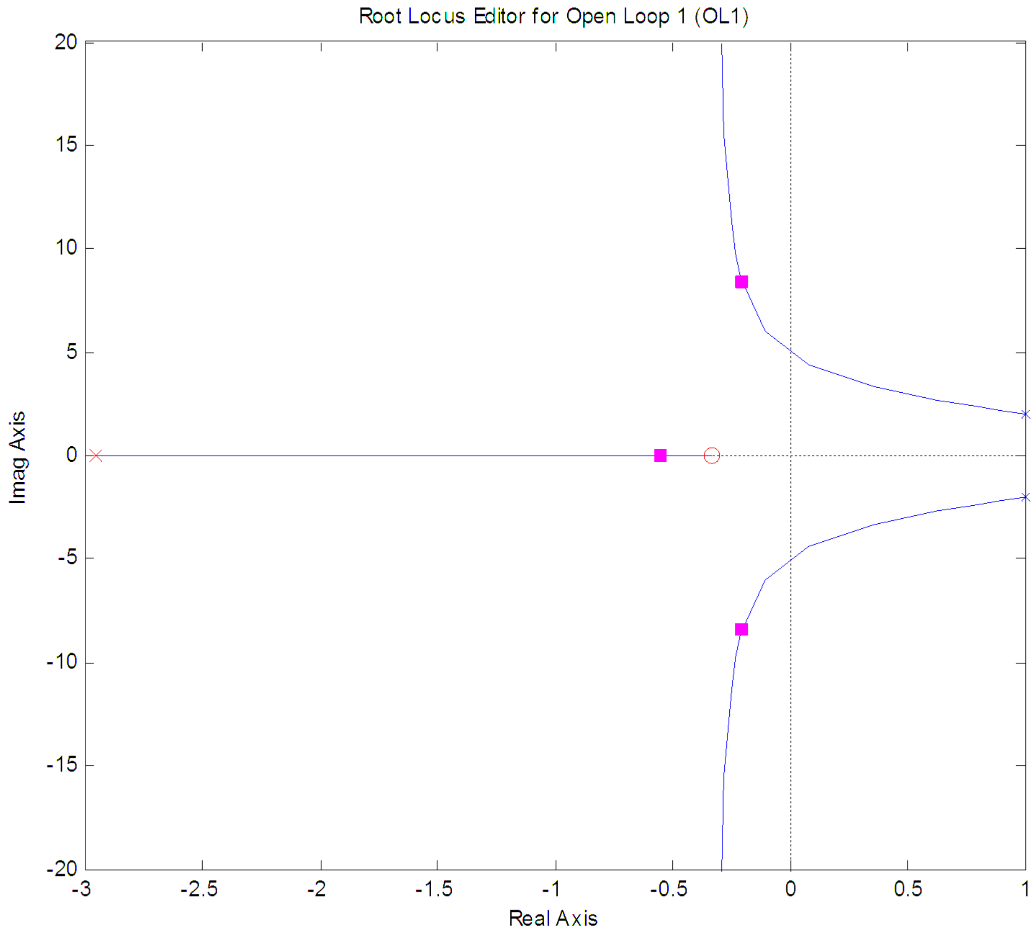
ECE-320, Quiz #3

Problems 1-3 refer to the following root locus plot for a unity feedback system with a plant and a controller.



1) Based on this root locus plot, the best estimate of the poles of the closed loop system are

a) -0.3+j7, -0.3-j7, -0.6 b) 1+j2, 1-j2, and -3

2) Is this a type one system? a) yes b) no

3) Is this a stable system for all values of the gain *k* ? a) yes b) no

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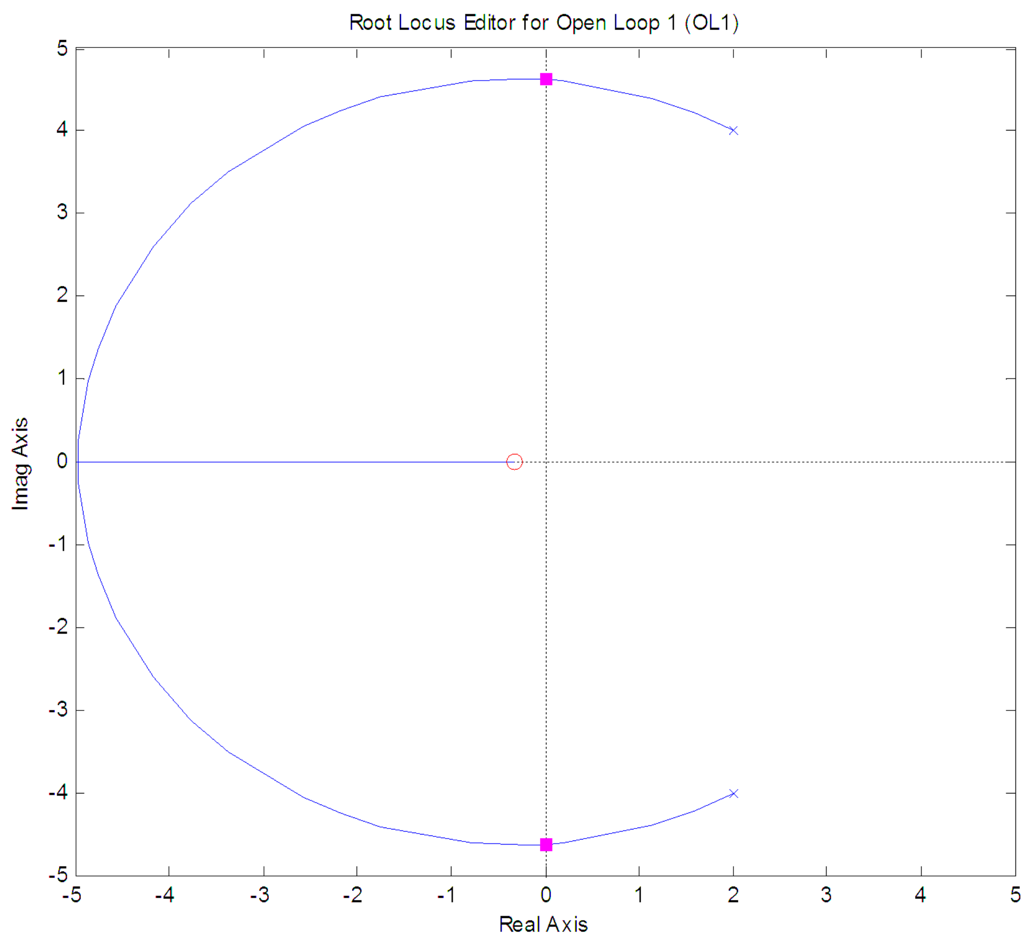
4) Consider the following root locus plot for a plant and controller in a unity feedback configuration.

If we want the system to be stable, should we

a) increase the gain b) decrease the gain c) do nothing



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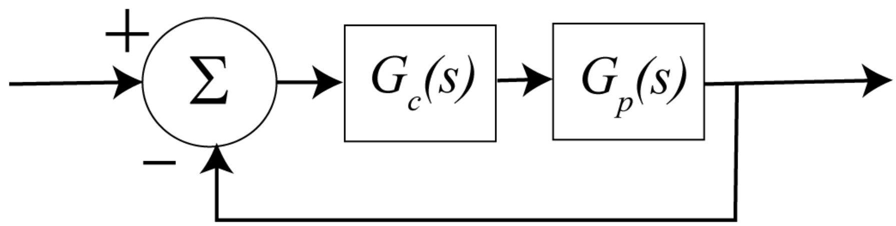
Problems 5-10 refer to the following feedback system with plant $G_p(s) = \frac{1}{(s+3)(s+4)}$



5) If we use a proportional controller $G_c(s) = k_p$ will the system remain stable for all positive values of k_p?

a) yes b) no

6) If we use a proportional controller $G_c(s) = k_p$ is there any value of k_p for which the settling time is less than 0.5 seconds?

a) yes b) no

7) If we use an integral controller $G_c(s) = \frac{k_i}{s}$ will the system remain stable for all positive values of k_i?

a) yes b) no

8) If we use an integral controller $G_c(s) = \frac{k_i}{s}$ is there any value of k_i for which the settling time is less than 0.5 seconds?

a) yes b) no

9) For which of the following PID controllers will the settling time be smaller as $k \to \infty$

a) $G_c(s) = \frac{k(s+2+j)(s+2-j)}{s}$ b) $G_c(s) = \frac{k(s+4+2j)(s+4-2j)}{s}$

c) the results will be the same

10) For which of the following PD controllers will the settling time be smaller as $k \to \infty$

a) $G_c(s) = k(s+5)$ b) $G_c(s) = k(s+10)$ c) the results will be the same

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11) The standard form for a PID controller is

$$G_c(s) = k_p + \frac{k_i}{s} + k_d s$$

For the following PID controller $G_c(s) = \frac{5(s^2 + 2s + 1)}{s}$ determine k_p, k_i, and k_d

For your ease, assume the form of convolution $y(n) = \sum_{k=-\infty}^{k=\infty} x(k)h(n-k)$ *in all of the following problems.*

12) The finite summation $S_N = \sum_{k=0}^{N} a^k$ is equal to

a) $\frac{1-a^N}{1-a}$ b) $\frac{1-a^{N-1}}{1-a}$ c) $\frac{1-a^{N+1}}{1-a}$ d) $\frac{1+a^{N+1}}{1-a}$ e) none of these

13) The finite summation $S = \sum_{k=-1}^{N+2} a^k$ is equal to

a) $a^{-1}\frac{1-a^{N+3}}{1-a}$ b) $a^1\left(\frac{1-a^{N+4}}{1-a}\right)$ c) $a^{-1}\left(\frac{1-a^{N+4}}{1-a}\right)$ d) $a^{-1}\left(\frac{1-a^{N-4}}{1-a}\right)$ e) none of these

14) For a discrete time system, $\delta(0)$ is equal to

a) 0 b) 1 c) ∞ d) it is not defined

15) If an LTI system with impulse response $h(n) = 4^{n-1}u(n-1)$ has input $x(n) = \delta(n)$, the output of the system is

a) $y(n) = 4^{n-1}u(n-1)\delta(n)$ b) $y(n) = 4^{n-1}u(n)$ c) $y(n) = 4^{n-1}u(n-1)$ d) none of these

16) If an LTI system with impulse response $h(n) = 3^{n+1}u(n)$ has input $x(n) = 3\delta(n-1)$, the output of the system is

a) $y(n) = 3^{n+1}u(n-1)$ b) $y(n) = 3^n u(n-1)$ c) $y(n) = 3^n u(n)$ d) none of these

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17) If an LTI system with impulse response $h(n) = 2^{n-1}u(n-1)$ has input $x(n) = 2\delta(n-1)$, the output of the system is

a) $y(n) = 2^{n-2}u(n-2)$ b) $y(n) = 2^{n}u(n-2)$ c) $y(n) = 2^{n-1}u(n-2)$ d) none of these

18) If an LTI system with impulse response $h(n) = 3\delta(n-1)$ has input $x(n) = 2\delta(n-1)$, the output of the system is

a) $y(n) = 3\times 2u(n-2)$ b) $y(n) = 3\times 2\delta(n-1)$ c) $y(n) = 3\times 2\delta(n-2)$ d) none of these

19) If an LTI system with impulse response $h(n) = 3^{n}u(n)$ has input $x(n) = u(n)$, the output of the system is

a) $y(n) = 3^{n}u(n)$ b) $y(n) = 3^{n+1}u(n)$ c) $y(n) = \frac{1-3^{n+1}}{1-3}u(n)$ d) $y(n) = \frac{1-3^{n-1}}{1-3}u(n)$

e) none of these

20) If an LTI system with impulse response $h(n) = 3^{n}u(n)$ has input $x(n) = 2^{n}u(n)$, the output of the system is

a) $y(n) = 3^{n}2^{n}u(n)$ b) $y(n) = 3^{n}\frac{1-\left(\frac{2}{3}\right)^{n+1}}{1-\frac{2}{3}}u(n)$ c) $y(n) = 2^{n}\frac{1-\left(\frac{3}{2}\right)^{n+1}}{1-\frac{3}{2}}u(n)$

d) $y(n) = \left[\frac{1-\left(\frac{1}{2}\right)^{n+1}}{1-\frac{1}{2}}\right]\left[\frac{1-\left(\frac{1}{3}\right)^{n+1}}{1-\frac{1}{3}}\right]u(n)$ e) none of these

21) The sum $S = \sum_{k=0}^{\infty} a^{k}$ will converge provided

a) $|a| > 1$ b) $|a| < 1$

22) If the sum $S = \sum_{k=0}^{\infty} a^{k}$ converges, it is equal to

a) $\frac{1}{1+a}$ b) $\frac{1}{1-a}$ c) $\frac{a}{1-a}$ d) $\frac{a}{1+a}$ e) none of these

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Root Locus Construction

Once each pole has been paired with a zero, we are done

1. *Loci Branches*

$$\underset{k=0}{poles} \rightarrow \underset{k=\infty}{zeros}$$

Continuous curves, which comprise the locus, start at each of the *n* poles of $G(s)$ for which $k=0$. As *k* approaches ∞ , the branches of the locus approach the *m* zeros of $G(s)$. Locus branches for excess poles extend to infinity.

The root locus is s**<u>ymmetric</u>** about the real axis.

2. *Real Axis Segments*

The root locus includes all points along the real axis to the left of an odd number of poles plus zeros of $G(s)$.

3. *Asymptotic Angles*

As $k \rightarrow \infty$, the branches of the locus become asymptotic to straight lines with angles

$$\theta = \frac{180^o + i360^o}{n-m}, i = 0, \pm 1, \pm 2, ..$$

until all $(n-m)$ angles not differing by multiples of 360^o are obtained. *n* is the number of poles of $G(s)$ and *m* is the number of zeros of $G(s)$.

4. *Centroid of the Asymptotes*

The starting point on the real axis from which the asymptotic lines radiate is given by

$$\sigma_c = \frac{\sum_i p_i - \sum_j z_j}{n-m}$$

where p_i is the i^{th} pole of $G(s)$, z_j is the j^{th} zero of $G(s)$, *n* is the number of poles of $G(s)$ and *m* is the number of zeros of $G(s)$. This point is termed the *centroid of the asymptotes*.

5. *Leaving/Entering the Real Axis*

When two branches of the root locus leave or enter the real axis, they usually do so at angles of $\pm 90^o$.