**CONTROL SYSTEMS ENGINEERING MtE - 328**

**Sixth Semester Spring 2023**

**Assignment 3**

**Name: Muhammad Ali**

**Reg.no: 19pwcse1801**

**Department: Computer System Engineering**

A picture containing text, font, white, algebra

Description automatically generated

**Solution: -**

**To find the root locus of the given transfer function, we will perform the analysis both manually and using MATLAB.**

**Manual Calculation of Root Locus:**

The given System is:

s^2(s+1) ^2 + k(s+2)

To find the root locus, we need to determine the poles and zeros of the transfer function. The poles are the values of 's' that make the transfer function equal to infinity, while the zeros are the values that make the transfer function equal to zero.

The transfer function can be rewritten as: G(s) = s^2(s+1)^2 + k(s+2) = 0

Let's simplify it further:

s^2(s^2 + 2s + 1) + k(s + 2) = 0 s^4 + 2s^3 + s^2 + k(s + 2) = 0

Now, let's analyze the poles and zeros:

Poles: s^4 + 2s^3 + s^2 = 0 s^2(s^2 + 2s + 1) = 0

From this equation, we can see that the poles are located at s = 0 and s = -1.

Zeros: k(s + 2) = 0

From this equation, we can see that there is a zero located at s = -2.

To determine the root locus, we need to consider the different cases based on the number of poles and zeros on the real axis. In this case, we have one zero at s = -2 and two poles at s = 0 and s = -1. Therefore, the root locus will consist of three branches starting from the poles and approaching the zero.

* To find the breakaway and break-in points, we need to perform further calculations.

**Number of Poles and Zeros**: The given transfer function has two poles at s = 0 and s = -1, and one zero at s = -2.

**Number of Branches:** The total number of branches in the root locus is equal to the number of poles or zeros, which is 3 in this case.

**Angle of Asymptotes:** The angle of asymptotes can be determined using the **following formula:** θ\_a = (180 \* (2n + 1)) / N where θ\_a is the angle of the asymptotes, n is the branch number (from 0 to N-1), and N is the total number of poles and zeros.

**In this case, N = 3, so the angles of asymptotes can be calculated as follows:** θ\_a1 = (180 \* (20 + 1)) / 3 = 60 degrees

θ\_a2 = (180 \* (21 + 1)) / 3 = 180 degrees

θ\_a3 = (180 \* (2\*2 + 1)) / 3 = 300 degrees

So, the angles of asymptotes for the root locus are 60 degrees, 180 degrees, and 300 degrees.

**Breakaway Points:** The breakaway points occur when the derivative of the open-loop transfer function with respect to s is equal to zero. In this case, we can find the breakaway points by differentiating the transfer function and solving for s.

Taking the derivative of the transfer function with respect to s:

dG(s)/ds = 2s(s+1)^2 + 2s(s+1) + k = 0

Simplifying the equation, we get:

2s^3 + 6s^2 + 4s + 2 + k = 0

**Note: -**The breakaway points can be found by solving this cubic equation for s.

Break-in Points: The break-in points occur when the root locus intersects the imaginary axis. In this case, since there are no complex poles or zeros, there are no break-in points on the imaginary axis.

**Manual diagram: -**

A notebook with writing on it

Description automatically generated with low confidence

**MATLAB code: -**

% Define the transfer function

num = [1 2];

den = [1 2 1];

G = tf(num, den);

% Plot the root locus

rlocus(G);

hold on;

**Locus diagram: -**

