

The construction of the root locus involves a systematic process to plot the loci of the closed-loop poles as a parameter, usually the gain or a controller parameter, varies. Here are the steps to construct the root locus:

Determine the Open-loop Transfer Function: Start with the open-loop transfer function of the system. It should be in the form of $G(s)H(s)$, where $G(s)$ represents the plant transfer function and $H(s)$ represents the controller transfer function, if applicable.

Determine the Poles and Zeros: Identify the poles and zeros of the open-loop transfer function. Poles are the values of 's' that make the denominator of the transfer function zero, while zeros are the values of 's' that make the numerator zero. Take note of the multiplicity (order) of each pole and zero.

Determine the Number of Branches and Asymptotes: Count the total number of poles and zeros, taking into account their multiplicities. The number of branches in the root locus will be equal to the number of poles. Also, determine the number of asymptotes, which is equal to the difference between the number of poles and zeros.

Calculate the Breakaway and Break-in Points: Solve the equation for the gain or controller parameter that determines the breakaway points. The breakaway points are the values of the parameter where the real and imaginary parts of a pair of complex conjugate poles coincide. Similarly, find the break-in points, which are the values of the parameter where a pole coincides with a zero.

Sketch the Real Axis: Determine the portions of the real axis that are part of the root locus. These portions lie to the left of an odd number of real-axis poles and zeros. Mark these points on the real axis.

Draw the Asymptotes: Draw the asymptotes of the root locus. Asymptotes are straight lines that start from the breakaway points and approach the angles determined by the number of asymptotes (equal angular spacing). The angles are calculated as $(2k + 1) * 180^\circ / N$, where k ranges from 0 to $N - 1$, and N is the number of asymptotes.

Calculate the Departure and Arrival Angles: For each branch of the root locus, calculate the departure angle (angle of the root locus at a pole) and the arrival angle (angle of the root locus at a zero). These angles can be calculated using mathematical formulas involving the poles, zeros, and the point on the real axis where the branch originates or ends.

Plot the Root Locus: Starting from the poles, follow the asymptotes until they intersect with the real axis or approach a zero or another pole. The root locus branches are curves that trace the loci of the closed-loop poles as the parameter varies. Plot these branches on the complex plane.

Check for Additional Points: Check for any additional points of interest, such as intersection points with the imaginary axis, the location of the centroid, or any other special features relevant to the system.

Analyze the Stability and Performance: Analyze the root locus plot to determine the stability and performance of the system. The system is stable if all the branches of the root locus lie in the left-half plane. If any branch crosses the imaginary axis into the right-half plane, the system becomes unstable. Additionally, observe the behavior of the root locus branches concerning performance criteria such as damping ratio, natural frequency, and settling time.