**ROOT LOCUS**

Root locus is a graphical method used in control theory to analyse how the roots (or poles) of the characteristic equation of a system vary with changes in a system parameter, typically a controller gain. The characteristic equation is derived from the transfer function of the system.

**NEED**

Stability Analysis

* Root locus helps engineers assess the stability of closed-loop control systems by analysing the movement of poles in the complex plane as a control parameter varies.
* Engineers can determine if the system will be stable for a given range of parameter values by examining the root locus plot. This information is crucial for ensuring safe and reliable system operation.

Controller Design

* Root locus analysis is a powerful tool for designing controllers, such as proportional, integral, and derivative (PID) controllers.
* Engineers can use root locus plots to select appropriate controller parameters (such as gains) to achieve desired stability and performance specifications, such as settling time, overshoot, and steady-state error.

Performance Optimization

* Root locus analysis allows engineers to optimize the performance of closed-loop control systems by adjusting controller parameters.
* By observing the movement of poles on the root locus plot, engineers can fine-tune controller parameters to meet specific performance requirements while maintaining stability.

Transient Response Analysis

* Engineers use root locus to analyze the transient response of closed-loop control systems, which describes how the system behaves immediately after a change in input.
* By examining characteristics such as rise time, settling time, and overshoot on the root locus plot, engineers can assess and optimize the transient response of the system.

Frequency Response Analysis

* Root locus indirectly provides insights into the frequency response characteristics of closed-loop control systems.
* Engineers can analyse the root locus plot to understand how changes in controller parameters affect the system's frequency response, such as bandwidth, damping ratio, and resonance frequency.

*IMPORTANT PARAMETERS TO BE CALCULATE DURING ROOT LOCUS PROCESS*

Asymptotes

* Asymptotes are straight lines in the complex plane that indicate the ultimate behavior of the root locus as the gain parameter approaches infinity.
* The number of asymptotes is equal to the difference between the number of poles and the number of zeros of the open-loop transfer function.
* Asymptotes start from the centroid and extend towards infinity at specific angles.

Angle of Asymptotes

* The angle of asymptotes is the angle made by the asymptotes with the real axis in the complex plane.
* The angle of asymptotes can be calculated using the formula: *θa*​=*n*(2*k*+1)/*π*​
* where *k*=0,1,2,…,*n*−1 is the total number of asymptotes.
* Asymptotes are symmetrically distributed around the real axis.

Centroid

* + The centroid is the average location of the root locus branches in the complex plane.
  + It is calculated as the sum of the poles minus the sum of the zeros, divided by the difference in their counts.

Breakaway and Break-in Points

* Breakaway points are points on the root locus where two branches merge and then separate, while break-in points are points where two branches originate from a single point.
* Breakaway and break-in points occur when the derivative of the root locus equation with respect to the gain parameter equals zero.
* At breakaway points, the root locus branches tangent to each other, while at break-in points, branches cross each other.