SNS COLLEGE OF TECHNOLOGY

Coimbatore-15
An Autonomous Institution

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Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

19ECT212 – CONTROL SYSTEMS

II YEAR/ IV SEMESTER

UNIT IV – STABILITY ANALYSIS

TOPIC 4.3,4 ROOT LOCUS TECHNIQUES & CONSTRUCTION

OUTLINE

- REVIEW ABOUT PREVIOUS CLASS
- INTRODUCTION- ROOT LOCUS TECHNIQUES
- RULES FOR CONSTRUCTION OF ROOT LOCUS
- ACTIVITY
- RULES FOR CONSTRUCTION OF ROOT LOCUS
- SUMMARY

INTRODUCTION

- The Root locus is the locus of the roots of the characteristic equation by varying system gain K from zero to infinity.
- We know that, the characteristic equation of the closed loop control system is

$$1+G(s)H(s)=0$$

- The points on the root locus branches satisfy the angle condition.
  - To know whether the point exist on root locus branch or not.
  - We can find the value of K for the points on the root locus branches by using magnitude condition.

INTRODUCTION

- Characteristic equation of closed loop control system is

$$1+G(s)H(s)=0$$

$$\Rightarrow G(s)H(s)=-1+j0$$

- The **phase angle** of G(s)H(s) is

$$\mathbf{G(s)H(s)=\tan^{-1}(0/1)=(2n+1)\pi}$$

- The **angle condition** is the point at which the angle of the open loop transfer function is an odd multiple of 180^0.

INTRODUCTION

- Magnitude of G(s)H(s) is –

$$|G(s)H(s)| = 1$$

- The magnitude condition is that the point (which satisfied the angle condition) at which the magnitude of the open loop transfer function is one.

RULES FOR CONSTRUCTION OF ROOT LOCUS

- **Rule 1 – Locate the open loop poles and zeros in the ‘s’ plane**
- **Rule 2 – Find the number of root locus branches.**
  - The root locus branches start at the open loop poles and end at open loop zeros. So, the number of root locus branches N is equal to the number of finite open loop poles P or the number of finite open loop zeros Z, whichever is greater
  - Mathematically, we can write the number of root locus branches N as

$$N = P \text{ if } P \geq Z$$

$$N = Z \text{ if } P < Z$$

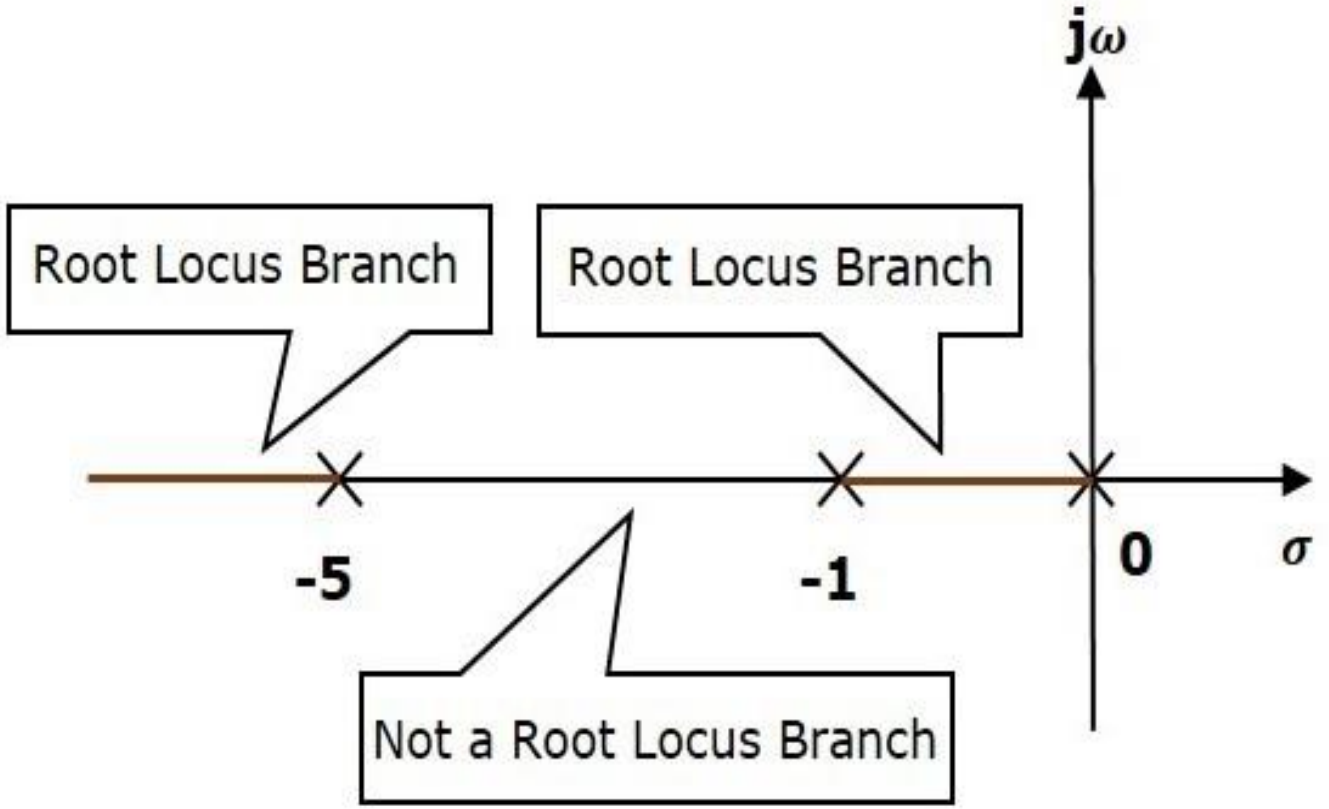
Rules for Construction of Root Locus

- **Rule 3 − Identify and draw the real axis root locus branches.**
  - If the angle of the open loop transfer function at a point is an odd multiple of 180°, then that point is on the root locus.
  - If odd number of the open loop poles and zeros exist to the left side of a point on the real axis, then that point is on the root locus branch.
  - Therefore, the branch of points which satisfies this condition is the real axis of the root locus branch.

ACTIVITY

GROUP DISCUSSION

RULES FOR CONSTRUCTION OF ROOT LOCUS



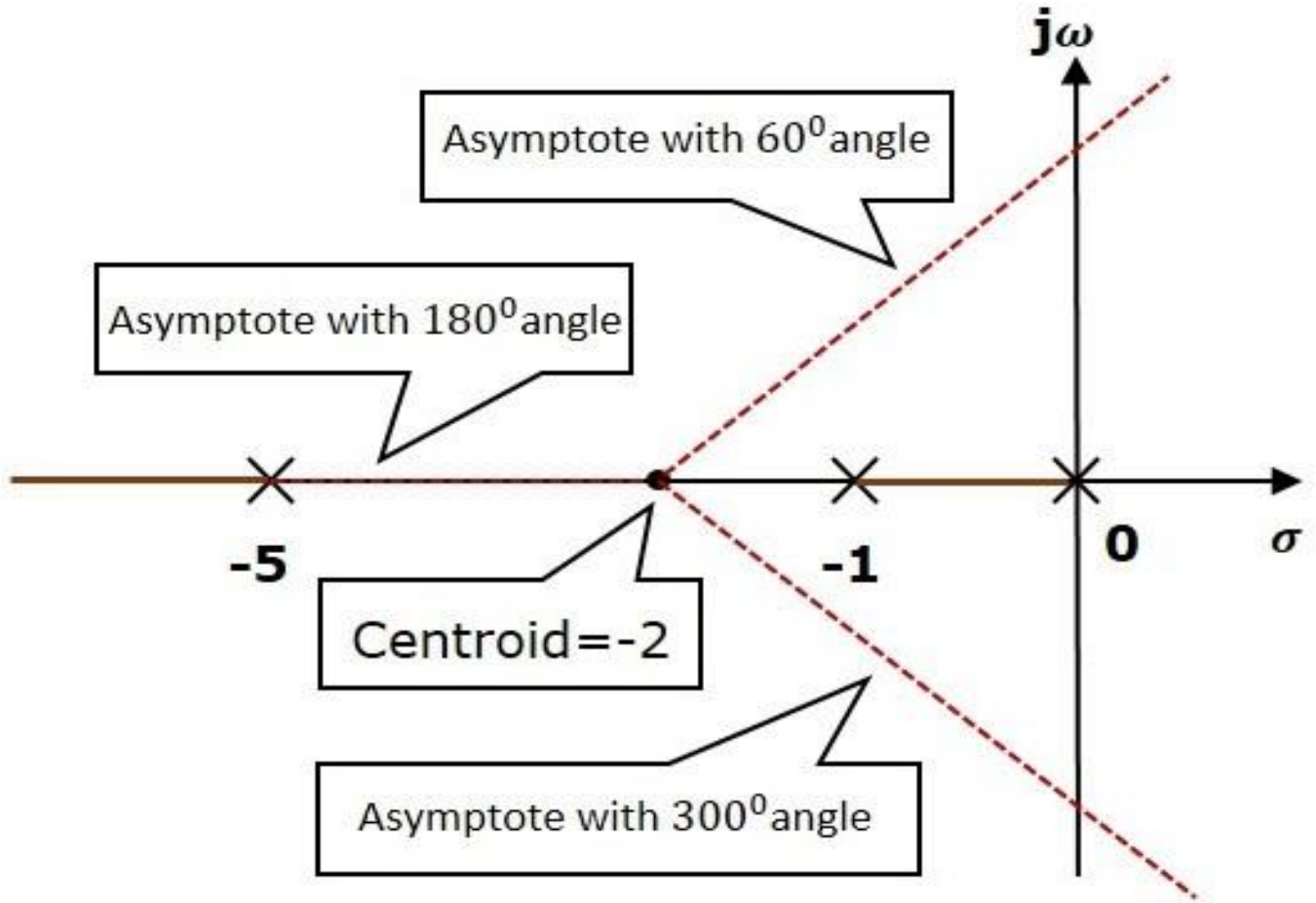
RULES FOR CONSTRUCTION OF ROOT LOCUS

- **Rule 4 – Find the centroid and the angle of asymptotes**
  - If P=Z, then all the root locus branches start at finite open loop poles and end at finite open loop zeros.
  - If P>Z, then Z number of root locus branches start at finite open loop poles and end at finite open loop zeros and P–Z number of root locus branches start at finite open loop poles and end at infinite open loop zeros.
  - If P<Z , then P number of root locus branches start at finite open loop poles and end at finite open loop zeros and Z–P number of root locus branches start at infinite open loop poles and end at finite open loop zeros.

Centroid = Sum of poles – Sum of zeros / (n-m)

The angle of asymptotes = 180(2q±1) / (n-m)

Rules for Construction of Root Locus



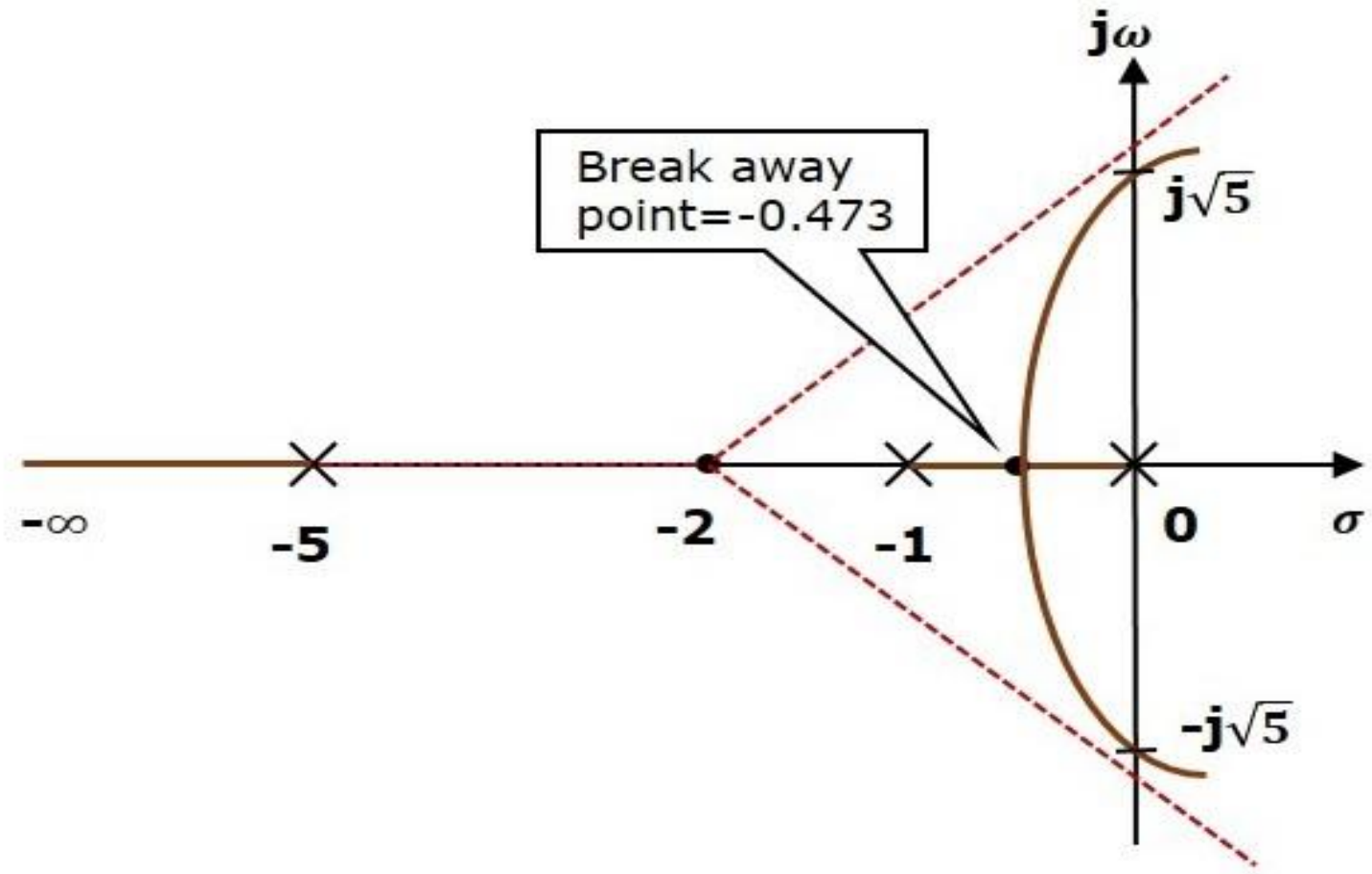
Rules for Construction of Root Locus

- **Rule 5 – Find Break-away and Break-in points.**
  - If there exists a real axis root locus branch between two open loop poles, then there will be a break-away point in between these two open loop poles.
  - If there exists a real axis root locus branch between two open loop zeros, then there will be a break-in point in between these two open loop zeros
- Write K in terms of ss from the characteristic equation 1+G(s)H(s)=0.
- Differentiate K with respect to s and make it equal to zero. Substitute these values of ss in the above equation.
- The values of ss for which the K value is positive are the **break points**.

Rules for Construction of Root Locus

- **Rule 6 – Find the angle of departure and the angle of arrival.**
  - The Angle of departure and the angle of arrival can be calculated at complex conjugate open loop poles and complex conjugate open loop zeros respectively
- **Rule 7 – Intersection point on imaginary axis**
  - Substitute $s=j\omega$ in the characteristic equation and equate real part and imaginary part to zero separately

Rules for Construction of Root Locus



SUMMARY

https://www.youtube.com/watch?v=sBO7R5GQpfI

https://www.youtube.com/watch?v=iR1A4vnops0