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Lecture 18 - PowerPoint (Product Activation Failed)

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Editing

EE 250: Control Systems Analysis

Module III: s-plane analysis

Lecture 19: Other Applications of Routh Array

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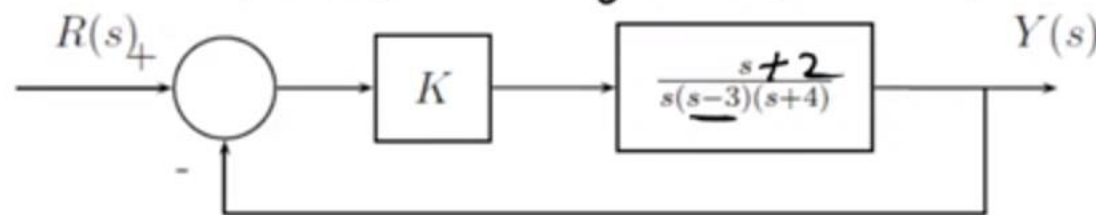


Direct Application

- DS stable*
- If all poles are in LHS plane \rightarrow *gf 1st column elements are all positive*
 - How many poles are there in RHS plane \uparrow .



Find range of k for which the system is stable



Find the range of K for which the closed loop system is stable.

$$\frac{Y(s)}{R(s)} = \frac{K(s+2)}{s(s-3)(s+4) + K(s+2)} = \frac{n(s)}{d(s)}$$

$$d(s) = s^3 + s^2 + (K-12)s + 2K = 0$$

System is always unstable $2K > 0 \Rightarrow K > 0$
 $K < -12$

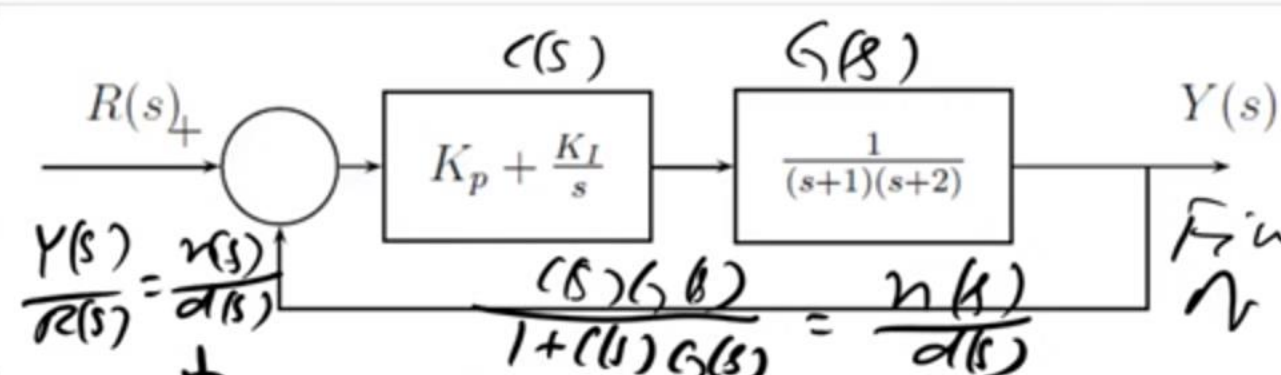
Routh array

$$\begin{array}{ccc|c} s^3 & 1 & K-12 & - \\ s^2 & 1 & 2K & - \\ s^1 & -(K+12) & 0 & - \\ s^0 & 2K & & - \end{array} \Rightarrow 0 > 0$$

$$-K-12 > 0$$

$$K+12 < 0$$

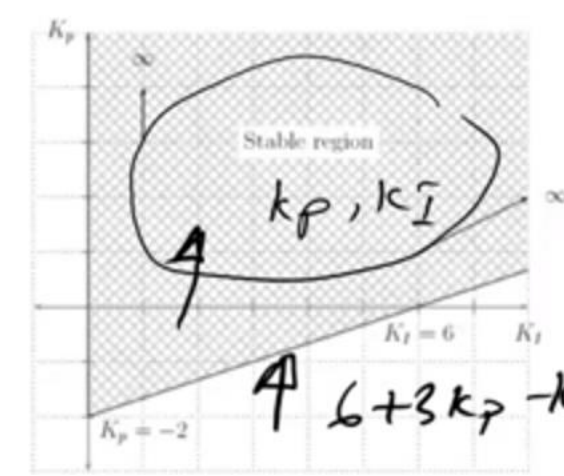
$$K < -12$$



Find value of K_p & K_I

$$\frac{Y(s)}{R(s)} = \frac{C(s)G(s)}{1 + C(s)G(s)} = \frac{n(s)}{d(s)}$$

$$d(s) = s^3 + 3s^2 + (2 + K_p)s + K_I = 0$$



Handwritten stability conditions:

$$K_p > \frac{K_I}{3}$$

$$K_I > 0$$

Handwritten stability conditions:

$$s^3 \quad 1 \quad 2 + K_p$$

$$s^2 \quad 3 \quad K_I$$

$$s^1 \quad \frac{6 + 3K_p - K_I}{3} > 0 \quad 0$$

$$s^0 \quad K_I > 0$$

or, $3K_p > K_I - 6$ $K_p = 3$

or, $K_p > \frac{K_I}{3} - 2$

$K_I = 10$



Routh test can find if roots are on $j\omega$ axis. This happens when an entire row becomes zero.

Example 9 (C). Consider the following characteristic polynomial

$$d(s) = s^5 + 5s^4 + 11s^3 + 23s^2 + 28s + 12$$

The corresponding Routh array

Handwritten: All zero row

s^5	1	11	28
s^4	5	23	12
s^3	6.4	25.6	0
s^2	3	12	0
s^1	0	0	0
new s^1	6	0	
s^0	12		

Handwritten: $3s^2 + 12 = 0$

The auxiliary equation

$$d_1(s) = 3s^2 + 12$$

$$\frac{d}{ds}d_1(s) = 6s$$

Since, all the elements in column 1 are positive, no roots are in the right half of s -plane. There exist a pair of conjugate poles on the $j\omega$ axis which can be obtained from the following equation

$$3s^2 + 12 = 0 \quad \checkmark \quad s^2 = -4$$

$$s^2 + 4 = 0$$

$$s_{1,2} = \pm j2$$