Transient Response stability

Chp ≈ 06.

· classification of systems:

Using Natural Respones:

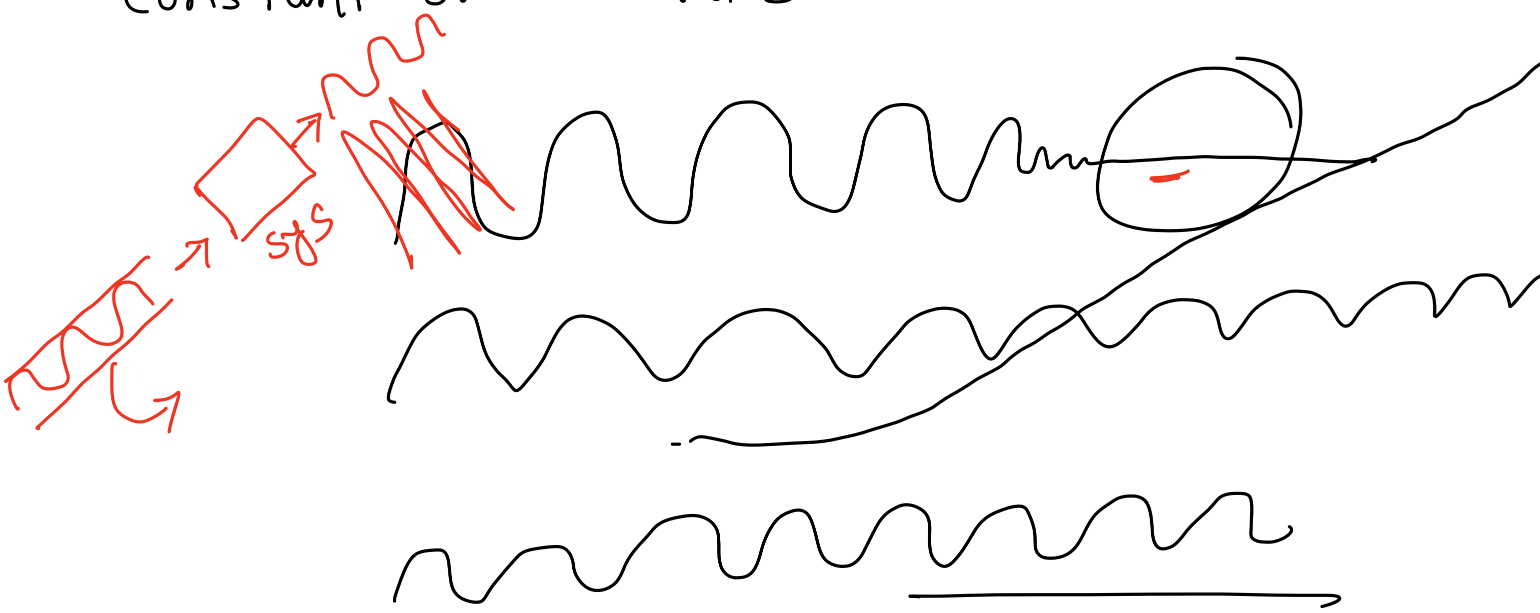
BIBO

1) stable: If Natural response zero; time approaches to infinity.

2) unstable: If Natural response infinite if time approaches to infinity.

BIUO

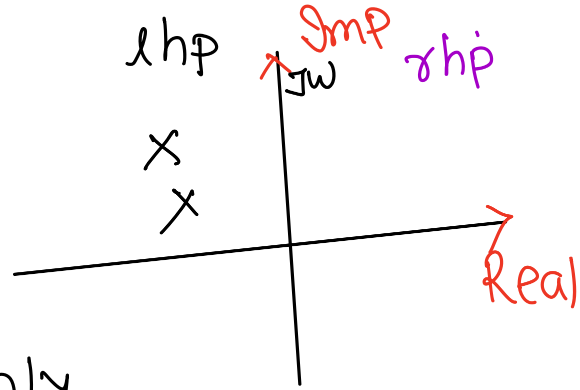
3) Marginally stabe: If natural response neither decays nor grows but remain constant or oscillates.



☐ Using the total Response: BIBO

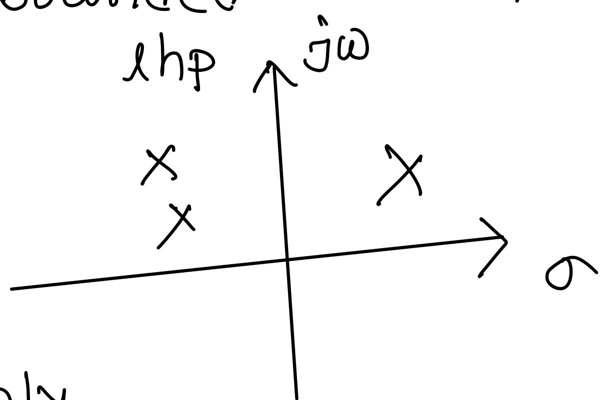
$H(S) = \frac{S-2}{S+5}$

Stable: if for every bounded i/p, o/p is bounded.

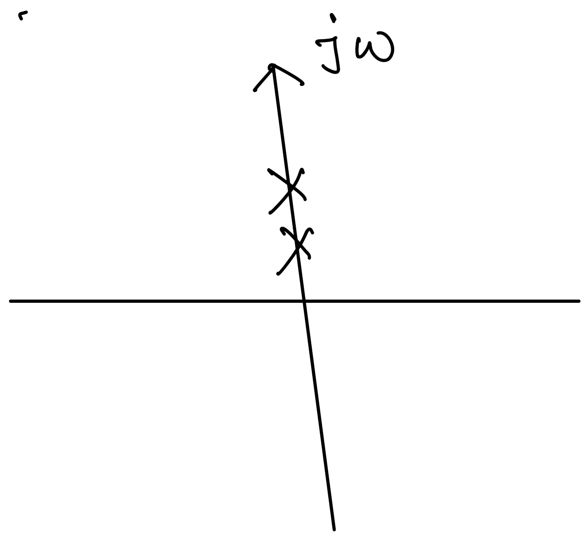


- stable systems have closed-loop transfer function with poles only in the left half plane.

Unstable: if for every bounded i/p, o/p is unbounded.



- stable systems have closed-loop transfer function with poles only in the Righthalf plane.



Marginally stable:

Routh-Hurwitz Criterion:

Advanges: tell us how many poles are in lhp, rhp and jw axis.

Limitations: Cannot tell the co-ordinates.

Designing Routh Table

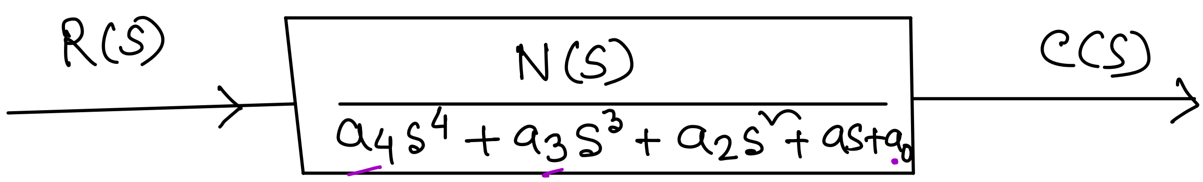


TABLE 6.2 Completed Routh table

s^4	a_4	a_2	a_0
s^3	a_3	a_1	0
s^2	$\dfrac{-\begin{vmatrix} a_4 & a_2 \\ a_3 & a_1 \end{vmatrix}}{a_3} = b_1$	$\dfrac{-\begin{vmatrix} a_4 & a_0 \\ a_3 & 0 \end{vmatrix}}{a_3} = b_2$	$\dfrac{-\begin{vmatrix} a_4 & 0 \\ a_3 & 0 \end{vmatrix}}{a_3} = 0$
s^1	$\dfrac{-\begin{vmatrix} a_3 & a_1 \\ b_1 & b_2 \end{vmatrix}}{b_1} = c_1$	$\dfrac{-\begin{vmatrix} a_3 & 0 \\ b_1 & 0 \end{vmatrix}}{b_1} = 0$	$\dfrac{-\begin{vmatrix} a_3 & 0 \\ b_1 & 0 \end{vmatrix}}{b_1} = 0$
s^0	$\dfrac{-\begin{vmatrix} b_1 & b_2 \\ c_1 & 0 \end{vmatrix}}{c_1} = d_1$	$\dfrac{-\begin{vmatrix} b_1 & 0 \\ c_1 & 0 \end{vmatrix}}{c_1} = 0$	$\dfrac{-\begin{vmatrix} b_1 & 0 \\ c_1 & 0 \end{vmatrix}}{c_1} = 0$

I System!

Exp:

$$H(S) = \frac{1000}{1\,S^3 + 10S^2 + 31S + 1030}$$

s^3	1	31	0
s^2	10	1030	0
s^1	-72	$\dfrac{-\begin{vmatrix}1 & 0\\ 10 & 0\end{vmatrix}}{10}=0$	0
s^0	103	0	0

$rhp = 2$

$lhp = 3 - rhp$
$= 3-2$
$= 1$

$rhp = 2$, $lhp = 3-2 = 1$

unstable.

System 2

$\boxed{2}$ $T(S) = \dfrac{10}{s^5+2s^4+3s^3+6s^2+5s+3}$

Soln:

s^5	1	3	5
s^4	2	6	3
s^3	$\cancel{0}\ \varepsilon$	$7/2$	0
s^2	$\dfrac{6\varepsilon-7}{\varepsilon}$	3	0
s^1	$\dfrac{42\varepsilon-49-6\varepsilon^2}{12\varepsilon-14}$	0	0
s^0	3	0	0

$-\dfrac{\begin{vmatrix}1 & 3\\ 2 & 6\end{vmatrix}}{2} = -\dfrac{6-6}{2} = 0$

Determine Signs in first column of a Routh table :-

Label	First Column	$\varepsilon = +$	$\varepsilon = -$
s^5	1	+	+
s^4	2	+	+
s^3	ε	+	−
s^2	$6\varepsilon-7/\varepsilon$	−	+
s^1	$42\varepsilon-49-6\varepsilon^2/12\varepsilon-14$	+	+
s^0	3	+	+

$rhp \approx 2$, $lhp = 5-2 = 3$

Unstable.

System-3

$\boxed{\text{Example: 6.4}}$ Determine the number of rhp-poles in the closed-loop transfer function.

$$T(S) = \frac{10}{S^5+7S^4+6S^3+42S^2+8S+56}$$

Sol^n:

S^5	1	6	8
S^4	$\cancel{7}$ 1	$\cancel{42}$ 6	$\cancel{56}$ 8
S^3	$\cancel{0}$ $\cancel{4}$ 1	$\cancel{0}$ $\cancel{12}$ 3	0
S^2	$3 = -\frac{\begin{vmatrix}1 & 6\\ 1 & 3\end{vmatrix}}{1}$	8	0
S^1	1/3	0	0
S^0	8	0	0

$$P(S) = 1S^4 + 6S^2 + 8$$

$$\frac{dP(S)}{dS} = 4S^3 + 12S + 0$$

Decision:

	Even $(s^0 \sim s^4)$ $n_1=4$	Rest (s^5) $n_2=1$	total 5
rhp	$0=x$	$0=y$	0
lhp	$0=x$	$n_2-y = 1-0 = 1$	1
$j\omega$	$n_1 - x - x$ 4	0	4

Marginally stable.

24/9/25

Sec: A: 2257, 1819, 2115, 1976, 2179, 1940, 2234
2127, 2255
1-5, 7-13, 15, 18, 21, 22, 26, 27, 29, 31, 32, 35, 36,
38, 39, 68

Sec B: 44, 46, 47, 51, 53, 56, 59, 64, 71~74, 78,
84, 90
1995.

Sec C: 912, 1100, 1110, 1510, 2198, 1081
93, 94, 97, 98, 100, 101~104, 06, 08, 110, 11,
14, 15, 17-19, 21, 23, 24, 29, 30, 32, 36, 38