3.2. MASSOVNE, SIS 1/5

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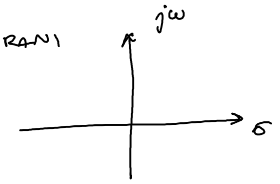
10:12

1) STABILNOST SUSTAVA

BIBO – Bounded Input Bounded Output

– prema karakterističnoj frekvenciji sustava

I KONTINUIRANI



$s = \sigma \pm j\omega$

$$y_H(t) = c_1 e^{s_1 t} + c_2 e^{s_2 t}$$

$$\lim_{t\to\infty}(y_H) = \lim_{t\to\infty}(c_1 e^{s_1 t} + c_2 e^{s_2 t}) \to 0 \quad \text{za } s_1, s_2 < 0$$

a) ZA JEDNOSTRUKE KORIJENE:

$Re\{s_i\} < 0, \forall i$ ... SUSTAV JE STABILAN

$Re\{s_i\} < 0, \exists i$ ... SUSTAV JE MARGINALNO STABILAN

$Re\{s_i\} > 0, \exists i$ ... NESTABILAN

b) VIŠESTRUKE KORIJENE:

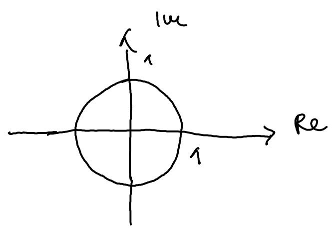
$Re\{s_i\} < 0, \forall i$ ... STABILAN SUSTAV

$Re\{s_i\} > 0, \exists i$ ... NESTABILAN SUSTAV

primjer: $\lim_{t\to\infty} (c_1 + c_2 t) e^{s_1 t}$ → nestabilan

II DISKRETNI

$$y_H(n) = c_1 q_1^n + c_2 q_2^n$$

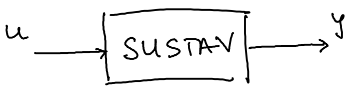


a) JEDNOSTRUKI (I VIŠESTRUKI): $|s_i| < 1, \forall i$: stabilan

$|s_i| = 1, \exists i$: marginalno stabilan

$|s_i| > 1, \exists i$ nestabilan

II FREKVENCIJSKA KARAKTERISTIKA



g – IMPULSNI ODZIV (na δ)

h – PRIJELAZNA FUNKCIJA (na μ(t))

$y = u * g$ ○—● $Y(s) = U(s) \cdot G(s)$

$$y = u * g \;\circ\!\!-\!\!\bullet\; Y(s) = U(s)\cdot G(s)$$

$$\hookrightarrow G(s) = \frac{Y(s)}{U(s)} \quad \ldots \text{ PRIJENOSNA FUNKCIJA SUSTAVA}$$

$$g(s) \;\circ\!\!-\!\!\bullet\; G(s)$$

$$G(j\omega) = G(s)\Big|_{s=j\omega}$$

Primjer 1.) $y'' + 3y' + 4y = u' + 2u$

$$y = Y(s)$$
$$y' = sY(s)$$
$$y'' = s^2 Y(s)$$

$$s^2 Y(s) + 3sY(s) + 4Y(s) = sU(s) + 2U(s)$$

$$Y(s)\,(s^2+3s+4) = U(s)\,(s+2)$$

$$G(s) = \frac{Y(s)}{U(s)} = \frac{s+2}{s^2+3s+4}$$

$$G(s) = \frac{Y(s)}{U(s)} = \frac{\text{karakt. jed. ulaza}}{\text{karakt. jed. izlaza}}$$

$$G(j\omega) = G(s)\Big|_{s=j\omega} = \frac{2+j\omega}{(j\omega)^2+3j\omega+4} = \frac{2+j\omega}{4-\omega^2+3j\omega}$$

$$|G(j\omega)| = \frac{\sqrt{2^2+\omega^2}}{\sqrt{(4-\omega^2)^2+(3j\omega)^2}} \qquad \text{AMPLITUDA}$$

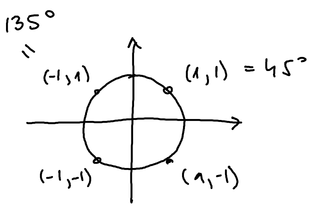
$$\phi = \operatorname{arc\,tg}\frac{\omega}{2} - \operatorname{arc\,tg}\frac{3\omega}{4-\omega^2} \qquad \text{FAZA}$$

- ODZIV NA SINUSNU FUNKCIJU :

$$u = U\cos(\omega_0 t + \varphi_u)$$
$$y = Y\cos(\omega_0 t + \varphi_y)$$

$$Y = U\,|G(j\omega)|\Big|_{\omega=\omega_0}$$
$$\phi = \phi_{ul.} + \measuredangle G(j\omega)\Big|_{\omega=\omega_0}$$

$$\operatorname{arc\,tg}\frac{1}{1} = 45^\circ$$
$$\operatorname{arc\,tg}\frac{-1}{-1} = 45^\circ + 180$$
$$\operatorname{arc\,tg}\frac{1}{-1} = -45^\circ + 180$$
$$\operatorname{arc\,tg}\frac{-1}{1} = -45^\circ$$



XV. TJEDAN , 5.

$$y''(t) + 2y'(t) + 5y(t) = u(t)$$

$u_1(t) = \sin(t)$, $t<0$
$u_2(t) = 2\sin(2t)$, $t>0$

TOTALNI ODZIV ?

$s^2 + 2s + 5 = 0$
$s_{1,2} = -1 \pm 2j$ $\rightarrow$ stabilan sustav
$y_H(t) = e^{-t}(A\cos(2t) + B\sin(2t))$

$$G(s) = \frac{1}{s^2+2s+5}$$

$$G(j\omega) = \frac{1}{5-\omega^2+2j\omega}$$

$$|G(j\omega)| = \frac{1}{\sqrt{(5-\omega^2)^2+(2\omega)^2}}$$

$$\measuredangle G(j\omega) = -\mathrm{arctg}\frac{2\omega}{5-\omega^2}$$

$y_{P_1}(t) = K\sin(t+\phi)$
$$K = 1\cdot|G(j\omega)|_{\omega=1} = \frac{\sqrt{20}}{20} = \frac{\sqrt{5}}{10}$$
$$\phi = 0 + (-\mathrm{arctg}\ \tfrac{2}{4}) = -26.56^\circ$$
$$y_{P_1}(t) = \frac{\sqrt{5}}{10}\sin(t-26.56^\circ)$$

PREBACIVANJE : $\measuredangle^\circ = \measuredangle^{rad}\,\frac{180}{\pi}$
$\measuredangle^{rad} = \measuredangle^\circ\,\frac{\pi}{180}$

$y_{P2}(t) = K\sin(2t+\phi)$
$$K = 2\cdot|G(j\omega)|_{\omega=2} = 2\cdot\frac{\sqrt{17}}{17}$$
$$\phi = 0 + \left(-\mathrm{arctg}\frac{4}{1}\right) = -75.96^\circ$$
$$y_{P2}(t) = 2\frac{\sqrt{17}}{17}\sin(2t-75.96)$$

- totalni odziv (nema početnih uvjeta zadanih)

$$y_t(t) = y_H(t) + y_P(t) = e^{-t}(A\cos(2t)+B\sin(2t)) + \frac{\sqrt{5}}{10}\sin(t-26.56^\circ)$$

$\downarrow$
SUSTAV JE STABILAN I NA POČETKU
POBUDE $-\infty$,
U NULI $y_H = 0$

$$y(t) = \begin{cases} \frac{\sqrt{5}}{10}\sin(t-26.56^\circ), & t<0 \\ \\ \end{cases}$$

$y_1(0) = \frac{\sqrt{5}}{10}\sin(-26.56^\circ) = -0.1 \rightarrow y(0^-) = -0.1 \curvearrowright y(0^+) = -0.1$
$y_1'(0) = \frac{\sqrt{5}}{10}\cos(-26.56^\circ) = 0.2 \rightarrow y'(0^-) = 0.2 \curvearrowright y'(0^+) = 0.2$

$$y_1'(0) = \frac{\sqrt{5}}{10}\cos(-26.56^\circ) = 0.2 \quad \longrightarrow \quad y'(0^-) = 0.2 \rightarrow y'(0^+) = 0.2$$

$$y_2(t) = y_H(t) + \frac{2\sqrt{17}}{17}\sin(2t - 75.96^\circ)$$

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2. DISKRETNI SUSTAVI

- $y(n-2) + 5y(n-1) + 6y(n) = u(n)$
  $u(n) = 12\mu(n)$

$y(-1) = 1 \quad y(-2) = 2$

$y_H(n) = Cq^n$

$Cq^{n-2}\,(q^2 + 5q + 6) = 0$

$q^2 + 5q + 6 = 0$

$q_{1,2} = -2, -3$ SUSTAV NIJE STABILAN

$y_H(n) = C_1(-2)^n + C_2(-3)^n$

$y_P(n) = K$

$K + 5K + 6K = 12$

$K = 1 \rightarrow y_P(n) = 1, \quad n \geq 0$

$y(n) = C_1(-2)^n + C_2(-3)^n + 1, \quad n \geq 0$

$6y(n) = u(n) - y(n-2) - 5y(n-1)$

$6y(0) = u(0) - y(-2) - 5y(-1)$

$y(0) = 5/6$

$6y(1) = u(1) - y(-1) - 5y(0)$

III Z-TRANSFORMACIJA

$$X(z) = \sum_{m=-\infty}^{\infty} x(m) z^{-m}$$ – dvostrana transformacija

- $x(n) = \alpha^n \mu(n)$

$$X(z) = \sum_{m=-\infty}^{\infty} \alpha^m \mu(m) z^{-m} = \sum_{m=0}^{\infty} \alpha^m z^{-m}$$

$$X(z) = \sum_{m=0}^{\infty} \left(\frac{\alpha}{z}\right)^m = \frac{1}{1-\frac{\alpha}{z}} = \frac{z}{z-\alpha}$$

- $x(n) = -\alpha^n \mu(-n-1)$

$$X(z) = \sum_{m=-\infty}^{\infty} -\alpha^m \mu(-m-1) z^{-m}$$

$$\mu(arg) = \begin{cases} 1, & arg \geq 0 \\ 0, & arg < 0 \end{cases} \qquad \mu(-m-1) = \begin{cases} 1 & m \leq -1 \\ 0 & m > -1 \end{cases}$$

$$X(z) = \sum_{m=-\infty}^{-1} -\alpha^m z^{-m} = \sum_{m=-\infty}^{-1} -\left(\frac{\alpha}{z}\right)^m = \left| \begin{matrix} m=-k & \\ m \to -1 & k \to 1 \\ m \to -\infty & k \to \infty \end{matrix} \right| = \sum_{k=1}^{\infty} -\left(\frac{\alpha}{z}\right)^{-k} = \sum_{k=1}^{\infty} -\left(\frac{z}{\alpha}\right)^k$$

$$= -\sum_{k=0}^{\infty}\left(\frac{z}{\alpha}\right)^k + 1$$

$$= \frac{-1}{1-\frac{z}{\alpha}} + 1 = \frac{z}{z-\alpha}$$

$$-\alpha^n \mu(-n-1) \circ\!\!-\!\bullet \frac{z}{z-\alpha}, \quad |z|<|\alpha|$$

$$\alpha^n \mu(n) \circ\!\!-\!\bullet \frac{z}{z-\alpha}, \quad |z|>|\alpha|$$

JEDNOSTRANA : $X(z) = \sum_{m=0}^{\infty} x(m) z^{-m}$

• LINEARNOST

$x(n) \circ\!\!-\!\bullet X(z) \qquad y(n) \circ\!\!-\!\bullet Y(z)$

$a x(n) \pm b y(n) \circ\!\!-\!\bullet a X(z) \pm b Y(z)$

• POMAK UNAPRIJED ZA k-koraka

$$x(n+k) \circ\!\!-\!\bullet z^k \left[X(z) - \sum_{m=0}^{k-1} x(m) z^{-m}\right]$$

• POMAK UNATRAG ZA k-KORAKA

$x(n) \circ\!\!-\!\bullet X(z)$

$$x(n-k) \circ\!\!-\!\bullet z^{-k} \left[X(z) - \sum_{m=-k}^{-1} x(m) z^{-m}\right]$$

• MNOŽENJE S α^n

$x(n) \circ\!\!-\!\bullet X(z)$

$x(n) \cdot \alpha^n \circ\!\!-\!\bullet X\left(\frac{z}{\alpha}\right)$

• MNOŽENJE S n

$x(n) \circ\!\!-\!\bullet X(z)$

$n^i x(n) \circ\!\!-\!\bullet \left(-z \frac{d}{dz}\right)^i X(z)$

III.6) INVERZNA Z-TRANSFORMACIJA

1.) $X(z) = \frac{z+1}{z^2+5z+6} = \frac{z+1}{(z+2)(z+3)} = \frac{C_{11}}{z+2} + \frac{C_{21}}{z+3} = \frac{-1}{z+2} + \frac{2}{z+3}$ / NEMA TAKVE Z-TRANSFORMACIJE (ne rastavljaj na parc. razlom.!)

$$X_1(z) = \frac{X(z)}{z} = \frac{z+1}{z(z+2)(z+3)} = \frac{C_{11}}{z} + \frac{C_{21}}{z+2} + \frac{C_{31}}{z+3} = \frac{\frac{1}{6}}{z} + \frac{\frac{1}{2}}{z+2} + \frac{-\frac{2}{3}}{z+3}$$

$$X(z) = z \cdot X_1(z) = \frac{1}{6} + \frac{\frac{1}{2}z}{z+2} - \frac{\frac{2}{3}z}{z+3}$$

$$\frac{1}{6}\delta(n) + \left(\frac{1}{2}(-2)^n - \frac{2}{3}(-3)^n\right)\mu(n)$$

2.) $X(z) = \frac{z^2-3z}{(z-1)(z-2)}$

$$X_1(z) = \frac{X(z)}{z} = \frac{\cancel{z}(z-3)}{\cancel{z}(z-1)(z-2)} = \frac{C_{11}}{z-1} + \frac{C_{21}}{z-2} = \frac{2}{z-1} + \frac{-1}{z-2}$$

$$X(z) = X_1(z) \cdot z = \frac{2z}{z-1} - \frac{z}{z-2}$$

$2(1)^n \mu(n) - (2)^n \mu(n)$

1. METODA („PARCIJALNI RAZLOMCI" – ali s X_1)

2. METODA

3) $X(z) = \frac{z^2 - 3z}{(z-1)(z-2)} = \frac{z^2-3z}{z^2-3z+2}$

$x(4) = \,?$

$z^2 - 3z : (z^2 - 3z + 2) = 1 - 2z^{-2} - 6z^{-3}$

$-(z^2 - 3z + 2)$

-2

$X(z) = \sum_{m=\infty}^{\infty} x(m) z^{-m} = x(0) + x(1) z^{-1} + x(2) z^{-2} + x(3) z^{-3} + \dots$

2. metodu koristimo samo kad nas traži $x(n)$ za neki mali konkretni n ($x(0)$?, $x(1)$? ..)

1. metoda za veliki n ($x(100)$?)

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POČETNA, KONAČNA VRIJEDNOST SIGNALA - u domaćoj zadaći (ne ispit)
(bez transformacija)

$y(\infty) \rightarrow$ konačna
$y(0) \rightarrow$ početna vrijednost

$$y(\infty) = \lim_{s \to 0} sY(s)$$
$$y(0) = \lim_{s \to \infty} sY(s)$$
} KONTINUIRANI

$$\lim_{n \to 0} y(n) = \lim_{z \to \infty} Y(z)$$
$$\lim_{N \to \infty} y(N) = \lim_{z \to 1} (1 - z^{-1}) Y(z)$$
} DISKRETNI

16. tjedan
5) $y(n) - y(n-2) = u(n)$

$y(n) \circ\!\!-\!\!\bullet\ Y(z)$

$$y(n-2) \circ\!\!-\!\!\bullet\ z^{-2}\left[Y(z) + \sum_{m=-2}^{-1} y(m) z^{-m}\right] = \frac{1}{z^2}\left[Y(z) + \underbrace{y(-2)}_{0} z^2 + \underbrace{y(-1)}_{0} z\right]$$

(pretpostavili smo da je to nula)

$$\circ\!\!-\!\!\bullet\ \frac{1}{z^2} Y(z)$$

$$Y(z) - Y(z) \cdot z^{-2} = U(z)$$
$$Y(z)(1 - z^{-2}) = U(z)$$
$$\frac{Y(z)}{U(z)} = \frac{z^2}{z^2 - 1}$$

$$u(n) = \mu(n) \circ\!\!-\!\!\bullet\ U(z) = \frac{z}{z-1}$$

$$Y(z) = G(z) \cdot U(z) = \frac{z^2}{z^2-1} \cdot \frac{z}{z-1} = \frac{z^3}{(z^2-1)(z-1)} = \frac{z^3}{(z-1)^2(z+1)}$$

$$Y_1(z) = \frac{c_{11}}{(z-1)^1} + \frac{c_{12}}{(z-1)^2} + \frac{c_{21}}{(z+1)^1}$$
$$= \frac{\frac{3}{4}}{z-1} + \frac{\frac{1}{2}}{(z-1)^2} + \frac{\frac{1}{4}}{(z+1)^1}$$

$$c_{11} = \frac{1}{(2-1)!} \lim_{z \to 1} \left\{ \frac{d^{2-1}}{dz^{2-1}} \left[\frac{z^2}{z+1}\right] \right\} = \lim \left(\frac{2z(z+1) - z^2 \cdot 1}{(z+1)^2} \right)$$

$$Y(z) = \frac{3}{4} \cdot \frac{z}{z-1} + \frac{1}{2} \cdot \frac{z}{(z-1)^2} + \frac{1}{4} \cdot \frac{z}{z+1}$$

$$\bullet\!\!-\!\!\circ\ \frac{3}{4}(1)^n \mu(n) + \frac{1}{2} n (1)^n \mu(n) + \frac{1}{4}(-1)^n \mu(n)$$

$$G(e^{j\omega}) = G(z)\big|_{z = e^{j\omega}}$$

$$G(e^{j\omega}) = G(z)\Big|_{z=e^{j\omega}}$$

→ FREKV. KARAKTERISTIKA DISKRETNIH SUSTAVA

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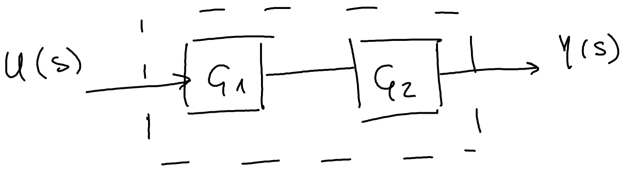
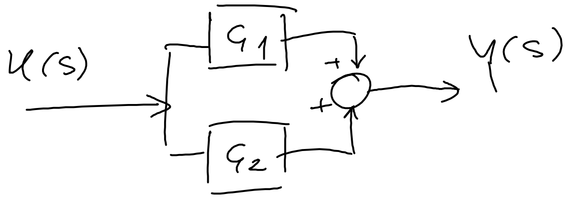
VI BLOKOVSKI DIJAGRAMI



KASKADA (serija)

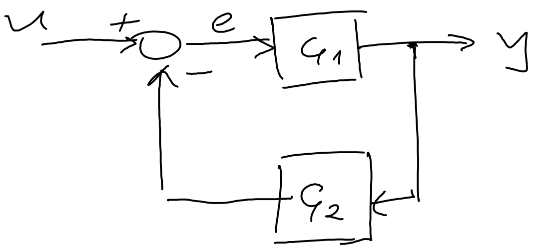
SUSTAV

$$G = G_1 \cdot G_2$$



PARALELNI SUSTAV

$$Y = UG_1 + UG_2 = U(G_1 + G_2)$$



SUSTAV S POVRATNOM VEZOM

$$e = u - G_2 y$$

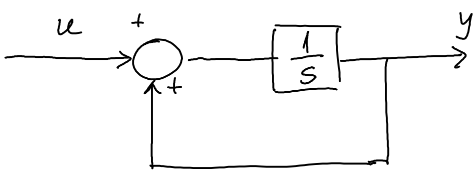
$$Y(s) = E(s) \cdot G_1(s)$$

$$Y(s) = \left(U(s) - G_2(s)Y(s)\right) G_1(s)$$

$$Y(s)\left(1 + G_1 G_2\right) = U(s) G_1(s)$$

$$\frac{Y(s)}{U(s)} = \frac{G_1}{1 + G_1 G_2}$$ → PRIJENOSNA FUNKCIJA

1.)



$u(t) = 4\mu(t)$

OPĆENITO: $Y(s) = \underbrace{U(s) \cdot G(s)}_{\text{MIRNI}} + \underbrace{\frac{\cdots}{\cdots}}_{\text{NEPOBUĐENI}} \rightarrow$ KARAK. JED. SUS.

$$G(s) = \frac{\frac{1}{s}}{1 - 1 \cdot \frac{1}{s}} = \frac{1}{s-1}$$

$$Y(s) = U(s) \cdot G(s) = \frac{4}{s} \cdot \frac{1}{s-1} = \frac{4}{s(s-1)} = \frac{C_{11}}{s} + \frac{C_{21}}{s-1} = \frac{-4}{s} + \frac{4}{s-1}$$

$$y(t) = (-4 + 4e^{t})\mu(t)$$

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V MATRIČNI PRIKAZ SUSTAVA

- kada ima više izlaza

$$\dot{x}(t) = A x(t) + B u(t)$$
$$y(t) = C x(t) + D u(t)$$

$$y_1' - 2y_2 = u$$
$$y_2' + 3y_1 + 5y_2 = u$$

$x_1 = y_1 \qquad x_2 = y_2$

$$x_1' - 2x_2 = u \longrightarrow x_1' = 2x_2 + u$$
$$x_2' + 3x_1 + 5x_2 = u \qquad x_2' = -3x_1 - 5x_2 + u$$

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \overbrace{\begin{bmatrix} 0 & 2 \\ -3 & -5 \end{bmatrix}}^{A} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \overbrace{\begin{bmatrix} 1 \\ 1 \end{bmatrix}}^{B} [u]$$

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \underbrace{\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}}_{C} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \underbrace{\begin{bmatrix} 0 \\ 0 \end{bmatrix}}_{D} [u]$$

$G(s) = H(s) = C\phi(s)B + D \longrightarrow$ PRIJENOSNA FUNKCIJA

$\phi(s) = (sI - A)^{-1} \longrightarrow$ MATRICA KARAKT. FREKV.

$Y(s) = U(s) \cdot H(s)$

$$sI - A = \begin{bmatrix} s & 0 \\ 0 & s \end{bmatrix} - \begin{bmatrix} 0 & 2 \\ -3 & -5 \end{bmatrix} = \begin{bmatrix} s & -2 \\ 3 & s+5 \end{bmatrix}$$

$$X = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \qquad X^{-1} = \frac{1}{ad-bc} \begin{bmatrix} d & -b \\ -c & a \end{bmatrix}$$

$$(sI - A)^{-1} = \frac{1}{s(s+5)-(-2)\cdot 3} \begin{bmatrix} s+5 & 2 \\ -3 & s \end{bmatrix} = \frac{1}{s^2+5s+6} \begin{bmatrix} s+5 & 2 \\ -3 & s \end{bmatrix}$$

$$= \frac{1}{(s+2)(s+3)} \begin{bmatrix} s+5 & 2 \\ -3 & s \end{bmatrix}$$

$$\phi(s) = (sI - A)^{-1} = \begin{bmatrix} \frac{s+5}{(s+2)(s+3)} & \frac{2}{(s+2)(s+3)} \\ \frac{-3}{(s+2)(s+3)} & \frac{s}{(s+2)(s+3)} \end{bmatrix}$$

$$(s+2)(s+3) \qquad (s+2)(s+3)$$

$$H(s) = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} \frac{s+5}{(s+2)(s+3)} & \frac{2}{(s+2)(s+3)} \\ \frac{-3}{(s+2)(s+3)} & \frac{s}{(s+2)(s+3)} \end{bmatrix} \cdot \begin{bmatrix} 1 \\ 1 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

$$H(s) = \begin{bmatrix} \frac{s+5}{(s+2)(s+3)} & \frac{2}{(s+2)(s+3)} \\ \frac{-3}{(s+2)(s+3)} & \frac{s}{(s+2)(s+3)} \end{bmatrix} \begin{bmatrix} 1 \\ 1 \end{bmatrix} = \begin{bmatrix} \frac{s+7}{(s+2)(s+3)} \\ \frac{s-3}{(s+2)(s+3)} \end{bmatrix}$$

SAD TRAŽIMO IMPULSNI ODZIV:

$$Y(s) = H(s) \cdot U(s)$$

$$Y(s) = \begin{bmatrix} \frac{s+7}{(s+2)(s+3)} \\ \frac{s-3}{(s+2)(s+3)} \end{bmatrix} \cdot 1 \quad \circ\!\!- \quad y(t) = \begin{bmatrix} 5e^{-2t} - 4e^{-2t} \\ -5e^{-2t} + 6e^{-2t} \end{bmatrix}$$

$\boxed{\text{ZADATAK 2.}}$ POPONOVLJENI ZI 2008.

$$A = \begin{bmatrix} -4 & 0 \\ 0 & -5 \end{bmatrix} \qquad B = \begin{array}{cc} \begin{bmatrix} -3 & -2 \\ 1 & 2 \end{bmatrix} \\ \downarrow\ \ \downarrow \\ u_1\ \ u_2 \end{array} \qquad C = \begin{bmatrix} 1 & 4 \end{bmatrix} \qquad D = \begin{array}{c} \begin{bmatrix} 0 & 0 \end{bmatrix} \\ \downarrow\ \ \downarrow \\ u_1\ \ u_2 \end{array}$$

ULAZI : 2 ulaza
IZLAZI : 1 izlaz

$$H(s) = C\phi(s)B + D$$

$$(sI - A) = \begin{bmatrix} s & 0 \\ 0 & s \end{bmatrix} - \begin{bmatrix} -4 & 0 \\ 0 & -5 \end{bmatrix} = \begin{bmatrix} s+4 & 0 \\ 0 & s+5 \end{bmatrix}$$

$$(sI - A)^{-1} = \frac{1}{(s+4)(s+5)} \begin{bmatrix} s+5 & 0 \\ 0 & s+4 \end{bmatrix} = \begin{bmatrix} \frac{1}{s+4} & 0 \\ 0 & \frac{1}{s+5} \end{bmatrix}$$

$$\begin{bmatrix} 1 & 4 \end{bmatrix} \begin{bmatrix} \frac{1}{s+4} & 0 \\ 0 & \frac{1}{\ldots} \end{bmatrix} = \begin{bmatrix} \frac{1}{s+4} & \frac{1}{s+5} \end{bmatrix} \cdot \begin{bmatrix} -3 & -2 \\ 1 & 2 \end{bmatrix}$$

$$[1\ \ 4]\begin{bmatrix} \text{[illegible]} & \text{[illegible]} \\ 0 & \frac{1}{s+5}\end{bmatrix} = \underbrace{\begin{bmatrix}\frac{\text{[illegible]}}{s+4} & \frac{\text{[illegible]}}{s+5}\end{bmatrix}}_{C\phi(s)} \cdot \underbrace{\begin{bmatrix}\text{[illegible]} & \text{[illegible]} \\ 1 & 2\end{bmatrix}}_{B}$$

$$H(s) = \begin{bmatrix} \frac{-3}{s+4} + \frac{4}{s+5} & \frac{-2}{s+4} + \frac{8}{s+5} \end{bmatrix}$$

$$\bullet\!\!-\!\!\circ$$

$$h(t) = \begin{bmatrix} -3e^{-4t} + 4e^{-5t} & -2e^{-4t} + 8e^{-5t} \end{bmatrix}$$