$\dot{x}(t) = f(x(t), u(t), t)$ $\quad u(t) = ?$

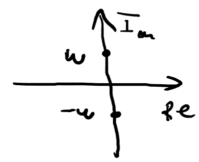
$\frac{\partial H}{\partial u} = 0$ $\quad \frac{\partial H}{\partial p} = \dot{x}(t)$ $\quad x_0$

$J(u) = \lambda(\quad) + \int_{t_0}^{t_f} \mathcal{L}(x(t), u(t))\, dt$

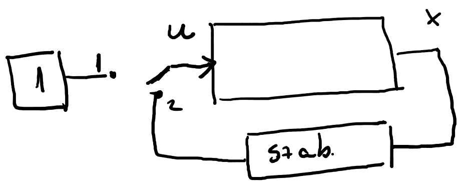
$\frac{\partial H}{\partial x} = -\dot{p}(t)$; $\quad p(t_f) = \frac{\partial \lambda}{\partial x}$

$H(x,u,t) = \mathcal{L}(\quad) + p^T(t) \cdot f(x(t), u(t), t)$

$H_p(s) = \frac{k}{s^2 + \omega^2} \longrightarrow s_{1,2} = \pm \omega j$



$|u(t)| \leq 1$ $\qquad J(u) = \int_{t_0}^{t_f} 1\, dt = t_f - t_0$ $\qquad \boxed{\forall x_0 \to 0}$



$x_1 \to y$

$x_2 \to \dot{y}$

$$\begin{pmatrix} \dot{x}_1(t) \\ \dot{x}_2(t) \end{pmatrix} = \begin{pmatrix} 0 & \omega \\ -\omega & 0 \end{pmatrix} \cdot \begin{pmatrix} x_1(t) \\ x_2(t) \end{pmatrix} + \begin{pmatrix} 0 \\ 1 \end{pmatrix} u(t)$$

$$H(x,u,p,t) = 1 + \begin{pmatrix} p_1(t) & p_2(t) \end{pmatrix} \cdot \begin{pmatrix} \omega \cdot x_2(t) \\ -\omega \cdot x_1(t) + u(t) \end{pmatrix} =$$

$$= 1 + p_1(t) \cdot \omega \cdot x_2(t) - \omega \cdot p_2(t) \cdot x_1(t) + \underline{p_2(t) \cdot u(t)}$$

$\frac{\partial H}{\partial u} = 0 \Rightarrow p_2(t) = 0 \rightarrow$ $\quad |u(t)| \rightarrow \{+1, -1\}$ $\quad u^* = \begin{cases} +1 \\ -1 \end{cases}$

$u(t) = -\operatorname{sign}(p_2(t))$

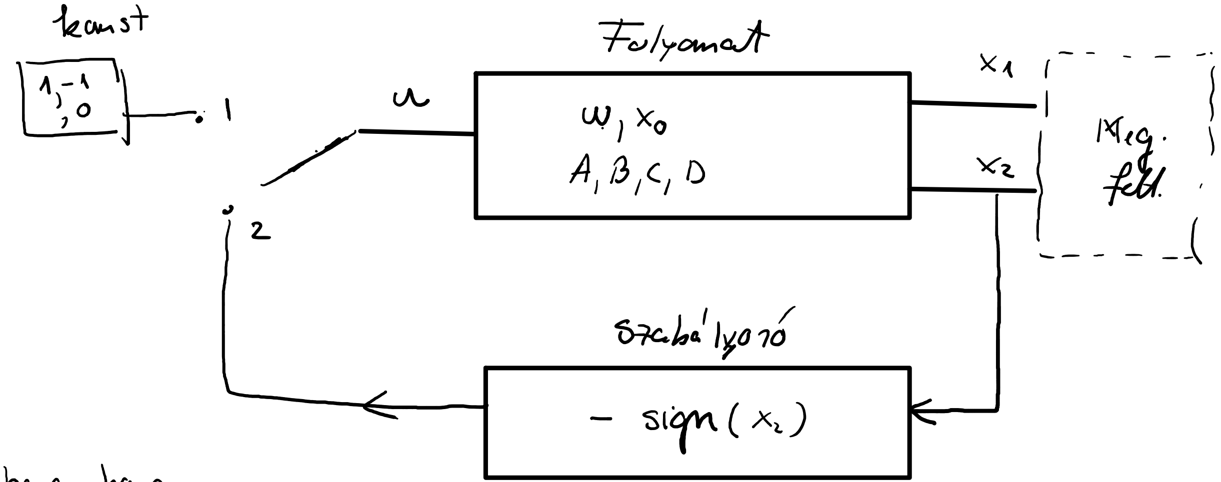
$\frac{\partial H}{\partial x_1} = -\dot{p}_1(t) \Rightarrow \begin{cases} -\dot{p}_1(t) = -\omega \cdot p_2(t) \\ -\dot{p}_2(t) = \omega \cdot p_1(t) \end{cases} \Rightarrow \begin{pmatrix} \dot{p}_1(t) \\ \dot{p}_2(t) \end{pmatrix} = \begin{pmatrix} 0 & \omega \\ -\omega & 0 \end{pmatrix} \cdot \begin{pmatrix} p_1(t) \\ p_2(t) \end{pmatrix}$

$\frac{\partial H}{\partial x_2} = -\dot{p}_2(t)$

A

$$\boxed{u(t) = -\operatorname{sign}(x_2(t))}$$

konst $\qquad T, \; t$



bang - bang

$x_1(t)$, $x_2(t)$, $u(t)$, $x_1(x_2)$ Scope, XY Graph

$$\left.\begin{array}{l} y_1 = x_1 \\ y_2 = x_2 \end{array}\right\} \Rightarrow \begin{pmatrix} y_1 \\ y_2 \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} \cdot \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} + \begin{pmatrix} 0 \\ 0 \end{pmatrix} u$$

$$|x_1| < \varepsilon \quad \& \quad |x_2| \leq \varepsilon \longrightarrow \text{STOP}$$