opg 1

$\dot{n} = -dn|n| + e$

$\dot{e} = -\lambda e + p$

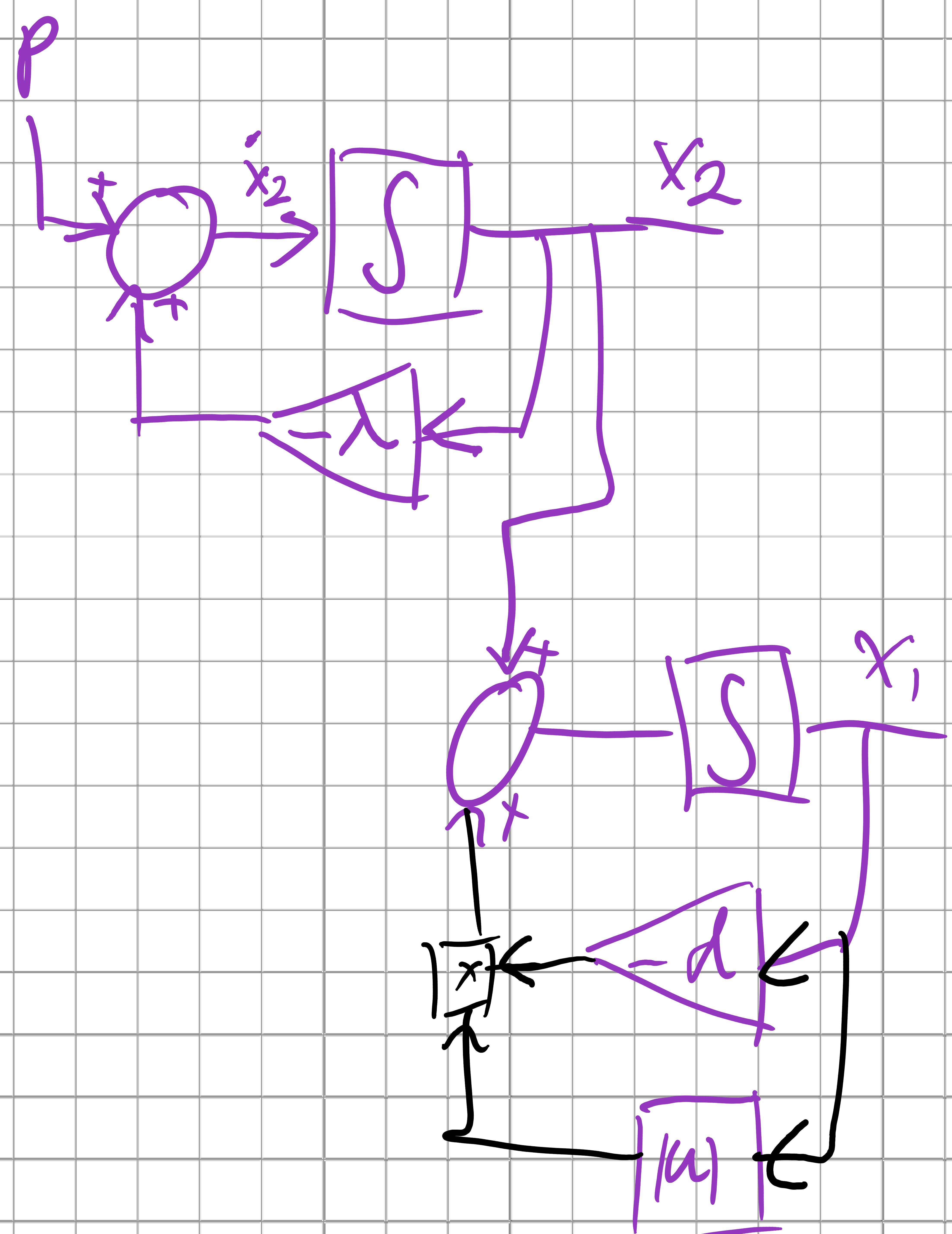
the system is non-linear because of $\underline{-dn|n|}$.

$\dot{x} = \begin{bmatrix} n \\ e \end{bmatrix} = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \Rightarrow \begin{matrix} \dot{x}_1 = -dx_1|x_1| + x_2 \\ \dot{x}_2 = -\lambda x_2 + p \end{matrix} \Rightarrow$

$f(x,u) = \begin{bmatrix} -dx_1|x_1| + x_2 \\ -\lambda x_2 + p \end{bmatrix}$ $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$

opg 2

$$f(x,u) = \begin{bmatrix} -d\, x_1 |x_1| + x_2 \\ -\lambda x_2 + p \end{bmatrix}$$



opg 3

$x_1 = n = 20$

$$\begin{bmatrix} -\alpha x_1 |x_1| + x_2 \\ -\lambda x_2 + p \end{bmatrix}$$

$0 = -0{,}005 \cdot 20 \cdot 20 + x_2$

$0 = -2 + x_2 \Rightarrow \underline{x_2 = 2}$

we then find the input

$0 = -10 \cdot 2 + p \Rightarrow 20 = p$

thus the non-zero equili-point is $\underline{\underline{x = \begin{bmatrix} 20 \\ 2 \end{bmatrix}}}$ at $\underline{\underline{p = 20}}$

OPG 4

$$\begin{bmatrix} -\alpha x_1|x_1| + x_2 \\ -\lambda x_2 + p \end{bmatrix}$$

$$0 = -0{,}005 \cdot 30 \cdot 30 + x_2$$

$$\underline{4.5 = x_2}$$

$$\downarrow$$

$$0 = -10 \cdot 4.5 + p \Rightarrow \underline{p = 45}$$

$$A = \begin{bmatrix} \frac{\partial f_1}{\partial x_1} = 2|30| = 60 & \frac{\partial f_1}{\partial x_2} = 1 \\ \frac{\partial f_2}{\partial x_1} = 0 & \frac{\partial f_2}{\partial x_2} = -10 \end{bmatrix}$$

We check the eigenvalues.

$\text{eig}(A) = \begin{bmatrix} 60 \\ -10 \end{bmatrix}$. Thus the system is <u>not</u> stable as they are <u>not</u> both negative

opg 7