**INSA**
TOULOUSE

TD 6

Limit cycle in a closed-loop system with a saturation function

(describing function)

Objective : Apply the describing function approximation to predict the presence of a limit cycle in a closed-loop system with a saturation function.

Consider the closed-loop system in the figure below. The control signal is limited by a saturation function. Its slope is unitary and the saturation limit is ± 20.
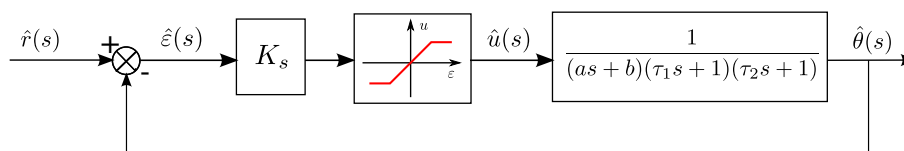
1. Compute the coefficient $N(A, \omega)$ of the describing function of the nonlinearity.

2. Numerical values are as follow, $a = 3$, $b = 0$, $\tau_1 = 0.1s$ and $\tau_2 = 0.02s$. Give the minimal value $K_{s_{min}}$ of K_s guaranteeing that a limit cycle exists. Give the value of the amplitude and the frequency of the limit cycle for $K_s = 2K_{s_{min}}$.

3. Is the limit cycle stable ?

4. Using Matlab, verify with numerical simulations the previous calculations.

5. Now $b = 1$, use Matlab to determine the condition of existence of a limit cycle. From the Nyquist plot, what is the minimal value of K_s (to have a limit cycle) ?