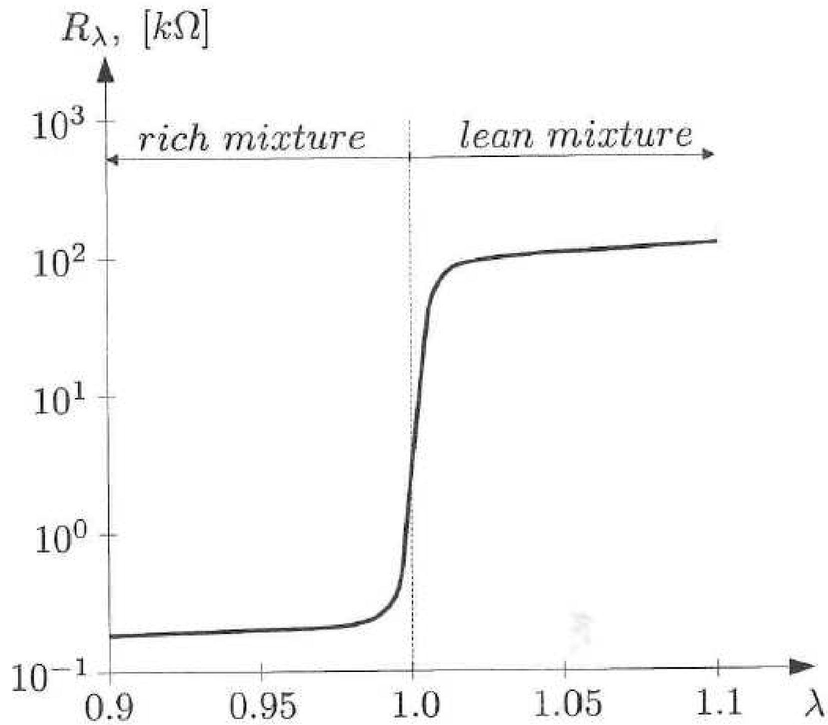
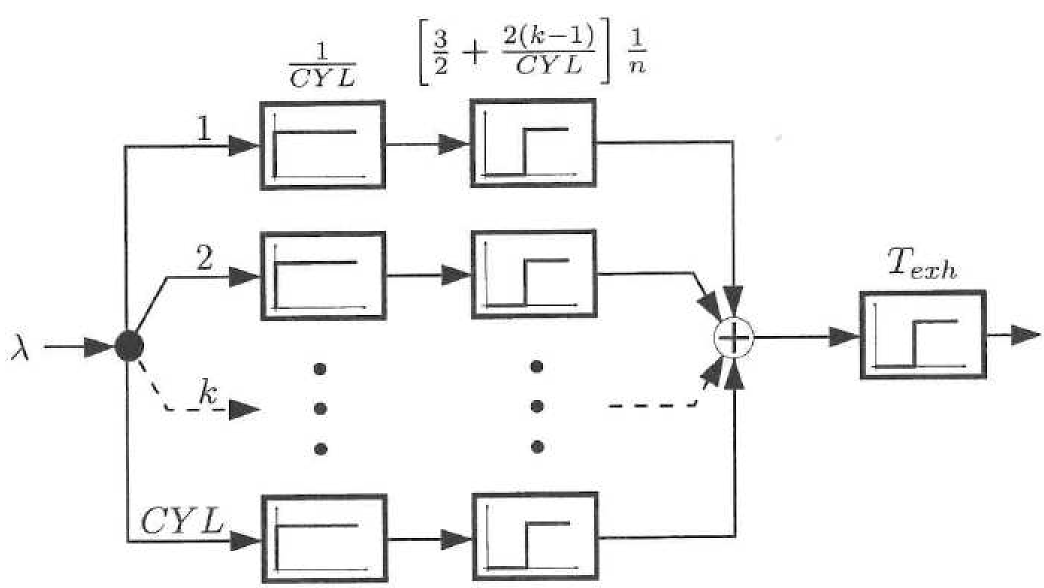
Lambda Control

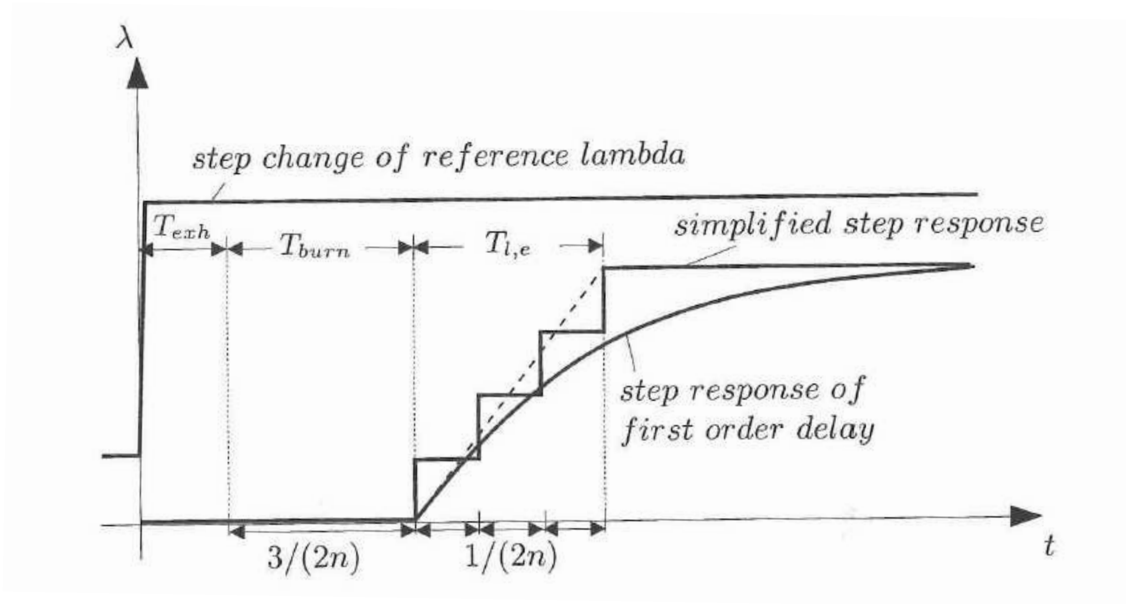
Example. The lambda sensor:



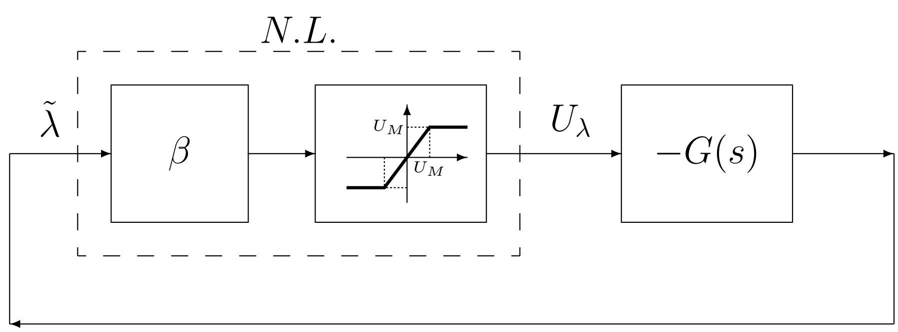
- The engine model:



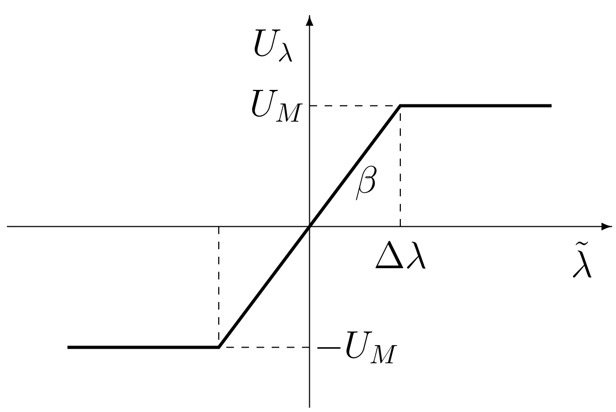
- The step response and its approximation with a first-order delayed system:



- The feedback system can be described as follows:



- The nonlinear element (N.L.) is a saturation with a central slope β:



$$X_1 = \Delta\lambda$$

$$\beta = \frac{U_M}{\Delta\lambda}$$

- The system $G(s)$ is composed by two parts:

$$G(s) = G_c(s) \cdot G_e(s)$$

where $G_c(s)$ is the controller and $G_e(s)$ describes the dynamics of the considered engine:

$$G_e(s) = \frac{K_e}{(1+\tau_e s)} e^{-T_d s}$$

- Choosing the controller $G_c(s)$ as follows:

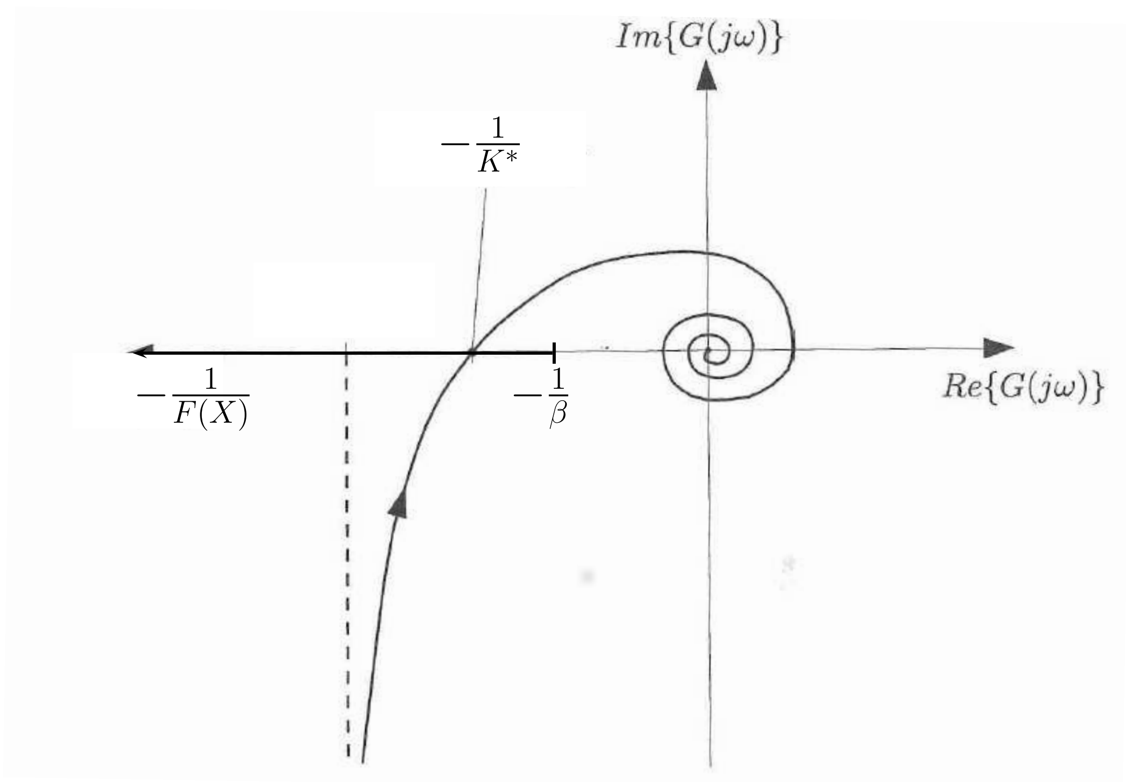
$$G_c(s) = \frac{K_c(1+\tau_e s)}{s}$$

one obtains that function $G(s)$ can be expressed as follows:

$$G(s) = K_c\,K_e\,\frac{e^{-T_d s}}{s}$$

where K_c is the parameter that has to be designed.

- The Nyquist diagram of function $G(s)$ has the following shape:



- The Routh parameters ω^* and K^* associated to system $G(s)$ are the following:

$$\omega^* = \frac{\pi}{2\,T_d}, \qquad K^* = \frac{\omega^*}{K_c\,K_e} = \frac{\pi}{2\,T_d\,K_c\,K_e}$$

- A limit cycle at the frequency ω^* appears in the system if:

$$\boxed{\beta > K^*} \quad \Rightarrow \quad \beta > \frac{\pi}{2\,T_d\,K_c\,K_e} \quad \Rightarrow \quad \boxed{K_c > \frac{\pi}{2\,T_d\,\beta\,K_e}}$$

- Simulink block scheme:

TO BE INSERTED

- Simulation parameters:

TO BE INSERTED

- Simulation results:

TO BE INSERTED