Control Engineering Laboratory - Cascade control and feed forward

Kjartan Halvorsen

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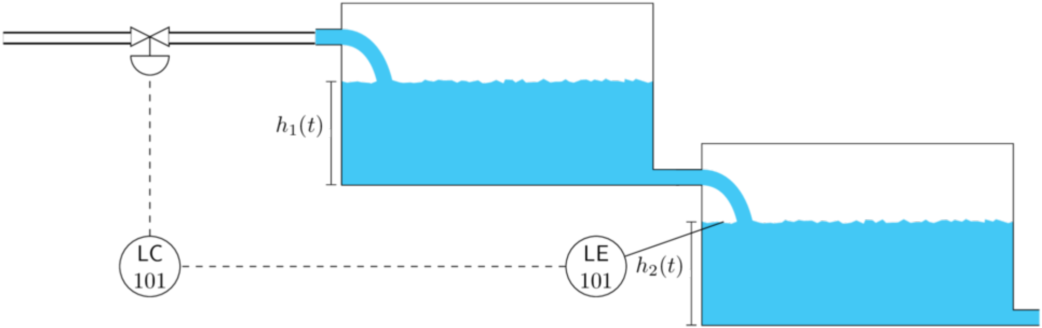
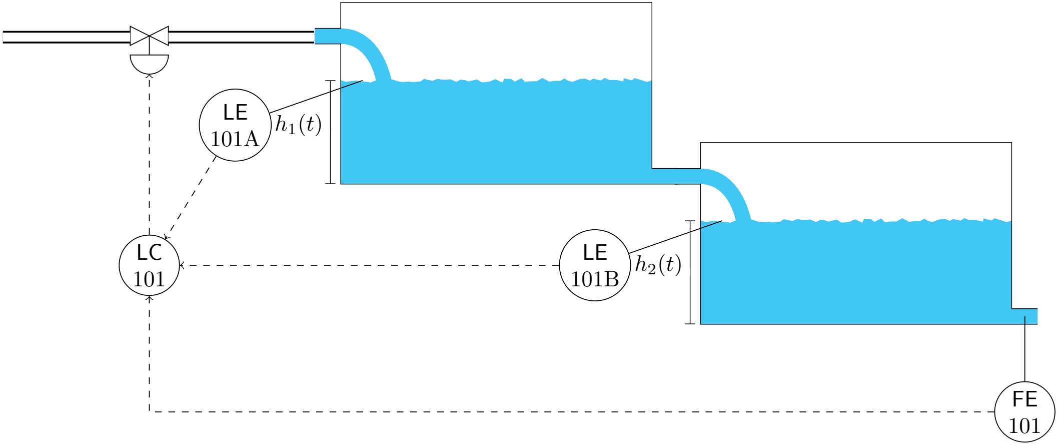
The two-tank model with one level sensor

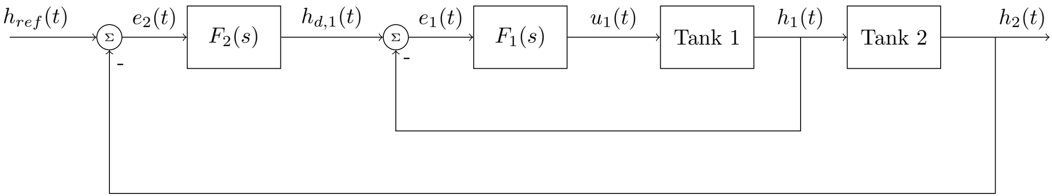


The two-tank model with two level sensors and one flow sensor

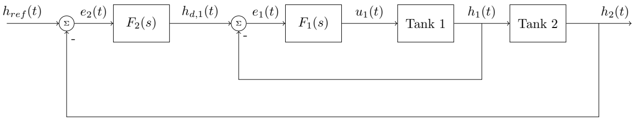


Key idea: We can improve the control using more information

Cascade control



Designing the inner loop



Have model $G_1(s) = \frac{K_1}{s\tau_1+1} = \frac{51}{51s+1}$. PI controller

$$F_1(s) = k_c\left(1 + \frac{1}{\tau_i s}\right) = k_c \frac{\tau_i s + 1}{\tau_i s}$$

Characteristic equation

$$s(s\tau_1 + 1) + k_c \frac{K}{\tau_i}(s\tau_i + 1) = 0$$

Choose τ_i and k_c to place the poles at any desired location in the LHP.

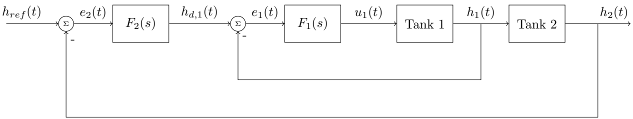
Exercise

Have characteristic equation

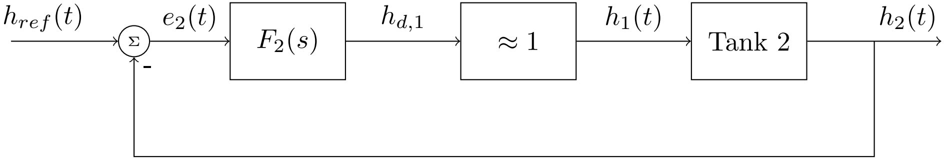
$$s(s\tau_1 + 1) + k_c \frac{K}{\tau_i}(s\tau_i + 1) = 0$$

Choose $\tau_i = \tau_1$, and then determine k_c which gives a pole in $s = -\frac{4}{\tau_1}$.

Designing the outer loop

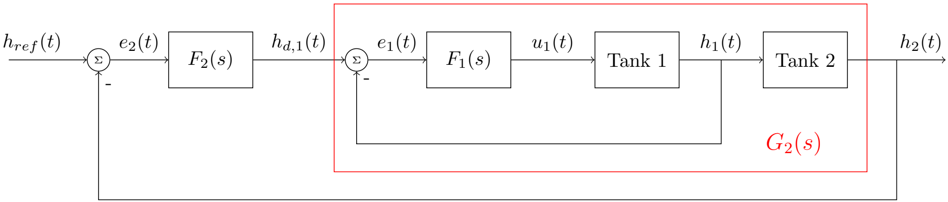


The output of the outer controller $F_2(s)$ is the desired level in tank 1. If the inner loop is sufficiently fast, we can approximate that the actual level in tank 1 is equal to the desired level.

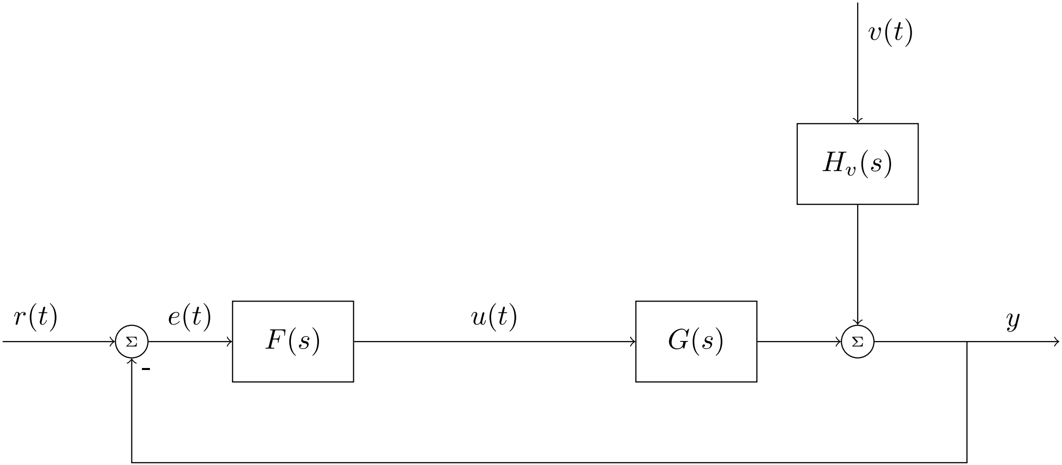


Designing the outer loop, contd

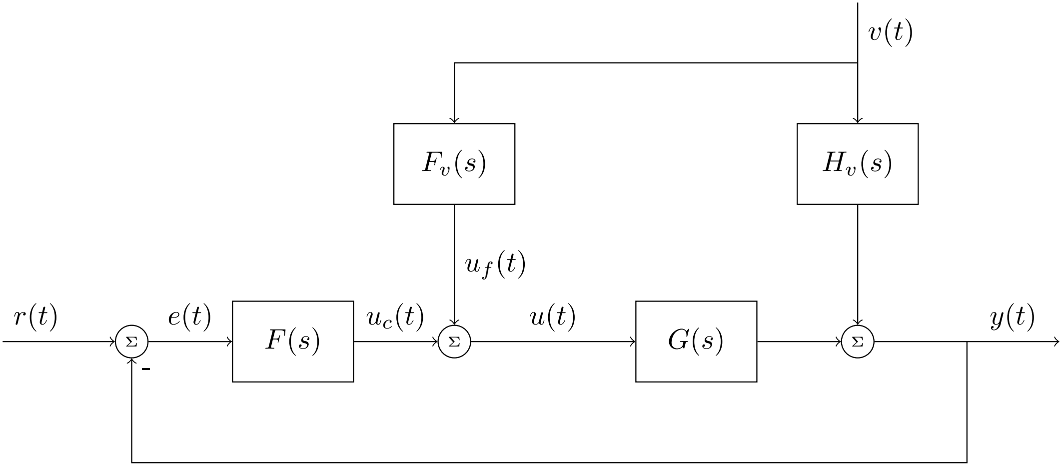
Alternatively, we can fit a model to the plant and the inner control-loop



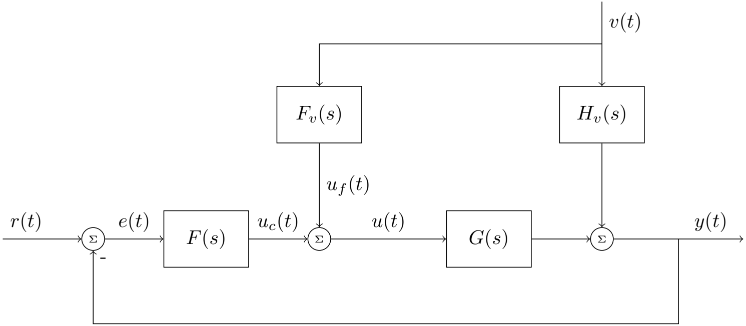
Feed forward from the disturbance



Feed forward from the disturbance



Feed forward from the disturbance



Clearly,

$$Y(s) = H_V(s)V(s) + G(s)\Big(U_C(s) + F_v(s)V(s)\Big)$$

Activity: Determine $F_v(s)$ that eliminates the effect of the disturbance!