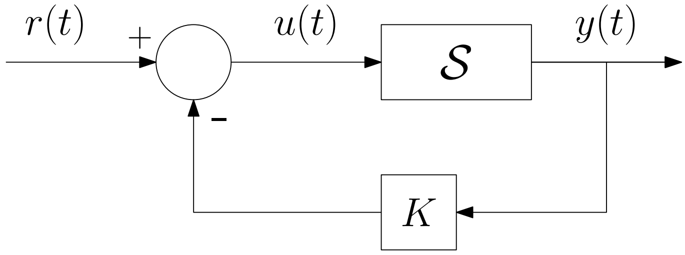
System Identification
Lab session #4 on System Identification

The file `SI_Lab4.mat` contains three input/output data sets:
`Z1=[y1 u1]`, `Z2=[y2 u2]`, `Z3=[y3 r3]`.

All data are sampled with sampling time $T_s = 0.5$ sec. The first two data sets are generated by performing two different experiments on the same unknown linear system $\mathcal{S}$, with input $u(t)$ and output $y(t)$. The third data set has been obtained by performing another experiment on the entire feedback system shown in figure, with input $r(t)$ and output $y(t)$. The gain K is an unknown positive constant.



In every identification procedure described in the following, use always the first 600 input/output samples to estimate the parameters of the models and the remaining 400 samples for the validation of the identified models.

1. For each data set `Z1` and `Z2`, find the best ARX model for system $\mathcal{S}$, according to the MDL criterion for order selection (consider only model with input/output delay $n_k = 1$).

2. Choose between the two data sets `Z1` and `Z2` the most appropriate one, to find the most suitable model representing system $\mathcal{S}$. In addition to the ARX models estimated at point 1, take into account several OE and ARMAX model classes. Justify the final model selection and the choice of the data set by using the validation techniques studied in the course. Report the model structure, the transfer function $G(z)$ from $u(t)$ to $y(t)$ and the corresponding FIT of the simulation error $\varepsilon_{sim}(t) = y(t) - G(z)u(t)$. By using the Matlab function `dcgain`, estimate the steady state gain from $u(t)$ to $y(t)$ (i.e., the asymptotic value of $y(t)$ when the input signal $u(t)$ is a unit step).

3. By using the data set `Z3`, find the most suitable model representing the feedback system shown in figure (with input $r(t)$ and output $y(t)$), taking into account different model classes, such as ARX, OE, ARMAX, BJ. Justify the final model choice by employing the validation techniques studied in the course and also the results obtained at point 2. Report the structure of the identified model, the FIT of the simulation error and an estimate of the frequency peak (in dB) of the transfer function from $r(t)$ to $y(t)$.

4. By using the models identified at points 2 and 3, devise a meaningful way to estimate the constant gain K in the feedback loop of the figure.