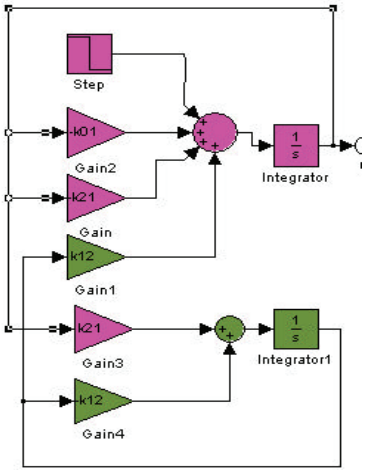
# C15 Clearance Identification - MATLAB / SIMULINK

**Numerical Simulation / Numerical Identification**

**Simulator:** MATLAB is a widely used software tool based on numerical vector and matrix manipulation. SIMULINK is a graphical extension for block oriented simulation. Those two parts can work together in both ways. Either by using m-functions as SIMULINK blocks or – as in this case – by controlling the SIMULINK model with an m-function. The computation of the following problem was done with the new MATLAB version 6.5 using also the Optimization Toolbox for task b.

**Model:** The system of differential equations is implemented in SIMULINK (see Figure 1). f(t) is implemented with a step block with sample time 0.1.




**Task a: Simulation of the System:** The simulink model is controlled from an m-file. For the different values $\tau_1$ = 0.5 min, $\tau_2$ = 3 min., $\tau_3$ = 240 min we get three different solutions (Figure 1) and the different values for $x_1(1.5)$ = 320.90, $x_1(4)$ = 302.58, $x_1(240)$ = 145.26. Even in the short time period of the first injection we can already see the clearance of the marker in the small subplot in Figure 2.

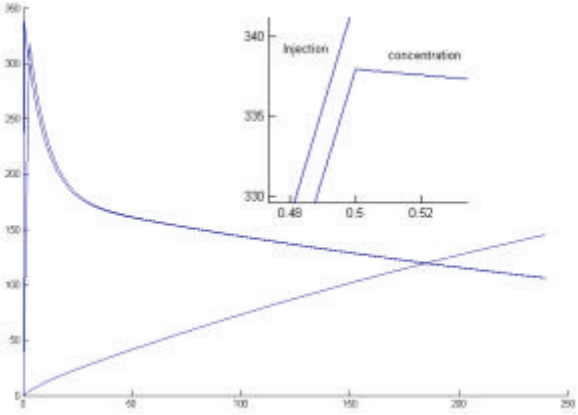



Figure 2: Plot of the 3 different solutions, task a

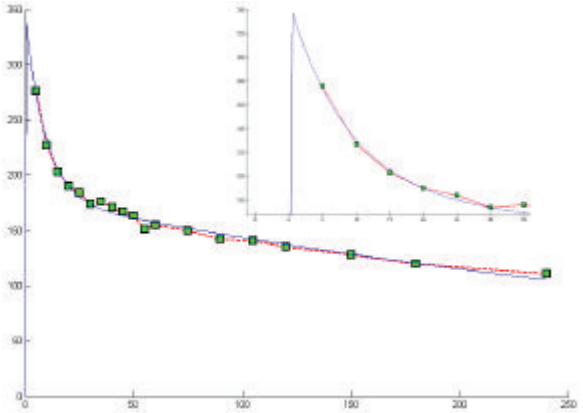


Figure 3: Data points and identified function

**Task b: Identification:** The SIMULINK model is called by an m-function `NiereFkt` (evaluation of cost functional) and then iterated using the optimization toolbox, in order to identify the parameters..

$V_1$ is not used in the simulink model (which is computed with the total amount of marker) but only in `NiereFkt`, where it is used to scale to concentration for adapting to the experimental data. So the procedure iterates 3 parameters in the simulink model and 1 in the m-file.

```
kopt = start values
options = optimset
  ('Large  Scale','off',
   'LevenbergMarquardt','on',
   'TolX',0.0001,
    'TolFun',0.0001);
kopt = lsqnonlin (@NiereFkt, kopt0,
       [],[],options,x1,x2,data,time);
```

Resulting parameters are $k_{01}$=0.0041, $k_{21}$=0.0494, $k_{12}$=0.0588, and $V_1$=7.31, the maximum of the function is 337.35, Clearance 30.33 and the residuum 260.81. Figure 3 shows the identified functions.

**Task c: Error Estimation:** Data are disturbed at MATLAB level, for each set of disturbed data the numerical identification is performed. The 1000 identifications resultet in mean value and standard deviation for the parameters: $k_{01}$=0.0041 (st.dev. = 0.0092), $k_{12}$=0.0586 (std. dev. = 0.0086), $k_{21}$=0.0503 (st.dev. = 0.0113), $V_1$=7.31 (st.dev. = 0.4207).

*Niki Popper, ARGESIM, c/o TU Vienna*
*npopper@osiris.tuwien.ac.at*