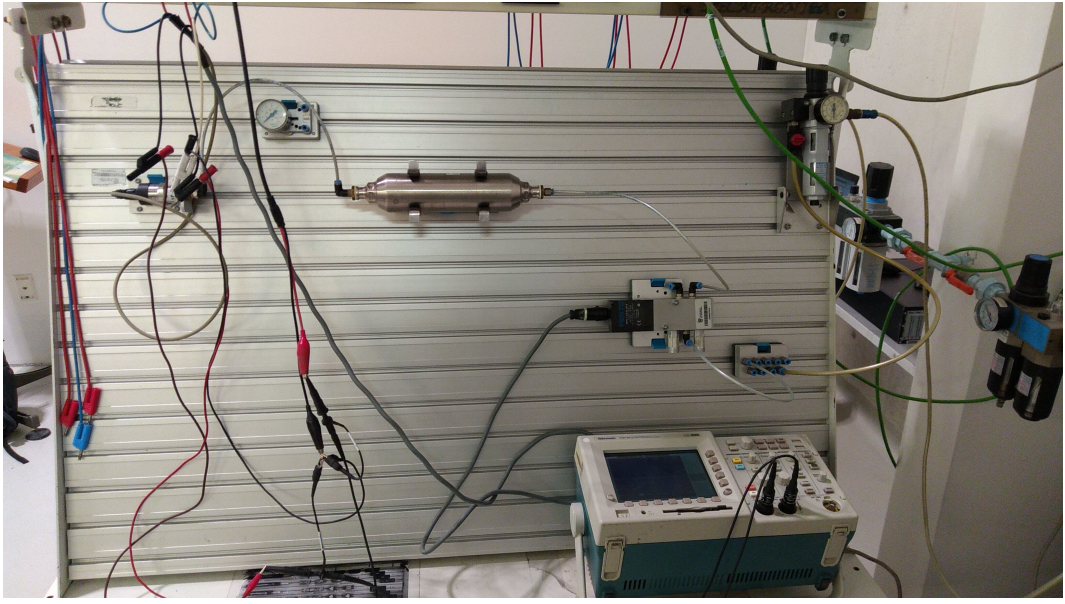
System identification of the pneumatic tank model

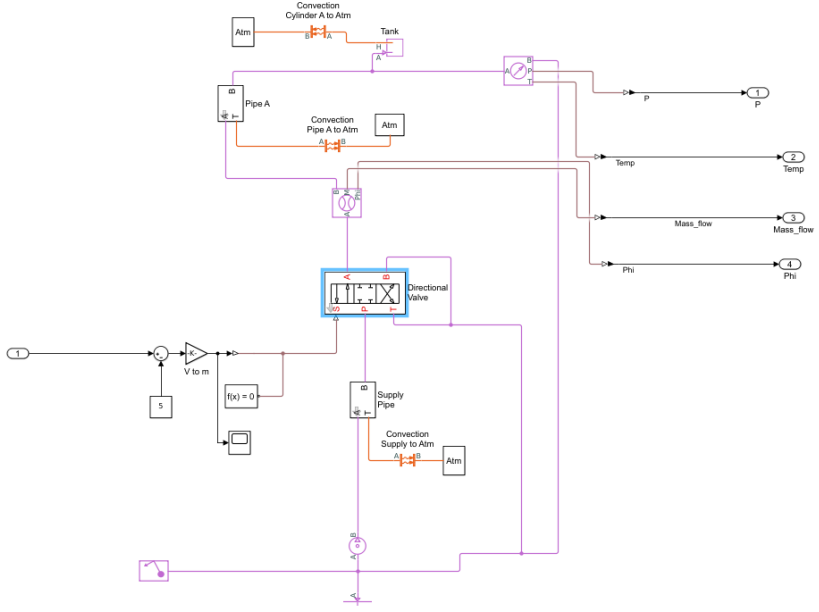
Kjartan Halvorsen

April 1, 2020

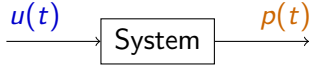
Lab experiment



Simulink simulation

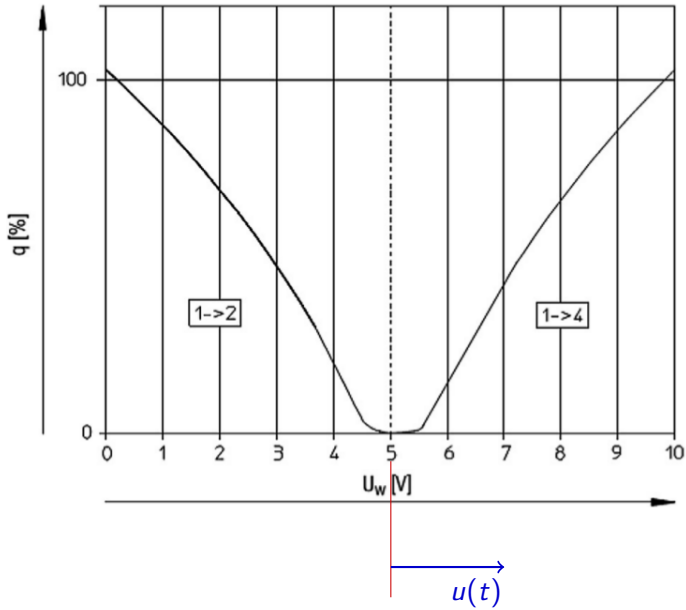


System identification



Given input-output data $\{(u(1), p(1)), (u(2), p(2)), \ldots, (u(N), p(N))\}$ find a good description of the system that generated the data.

Flow through the valve



Nonlinear model 1

Flow into the tank, $V_{in}(t) > 5$

$$\dot{p}(t) = a_0 \underbrace{(V_{in}(t) - 5)}_{u(t)} \sqrt{|\underbrace{p_s - p(t)}_{\Delta p(t)}|}$$

Flow out the tank, $V_{in}(t) < 5$

$$\dot{p}(t) = a_0 u(t) \sqrt{|\underbrace{p(t) - 0}_{\Delta p(t)}|}$$

Nonlinear model 2

$$\dot{p}(t) = a_0 u(t) |\Delta p(t))|^{a_1}$$

Converting to a regression model which is linear in the parameters

$$\dot{p}(t) = a_0 u(t) |\Delta p(t)|^{a_1}$$

Take the logarithm of the equation to get

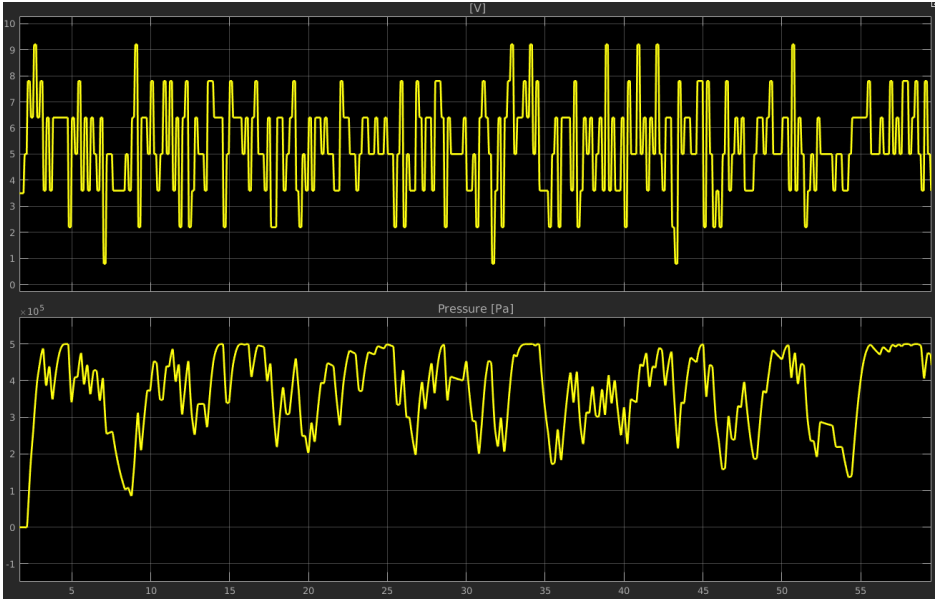
$$\log \dot{p} = \log a_0 + \log u + a_1 \log |\Delta p|$$

Linear model

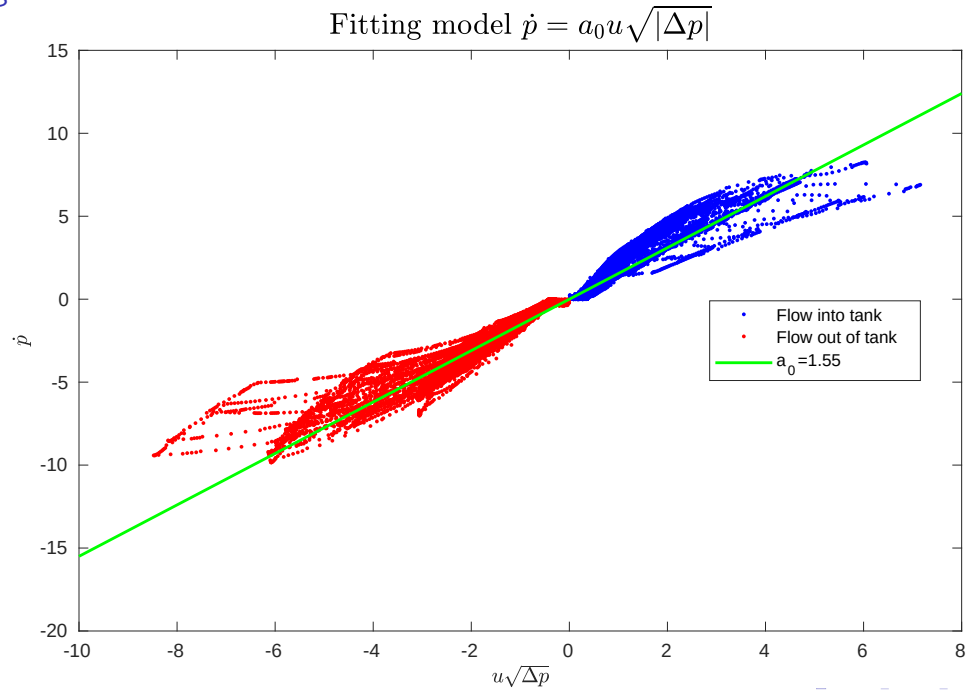
Introduce $y(t) = p(t) - p_0$, where p_0 is a chosen operating point.

$$\dot{p}(t) = \dot{y}(t) = -ay(t) + ku(t)$$

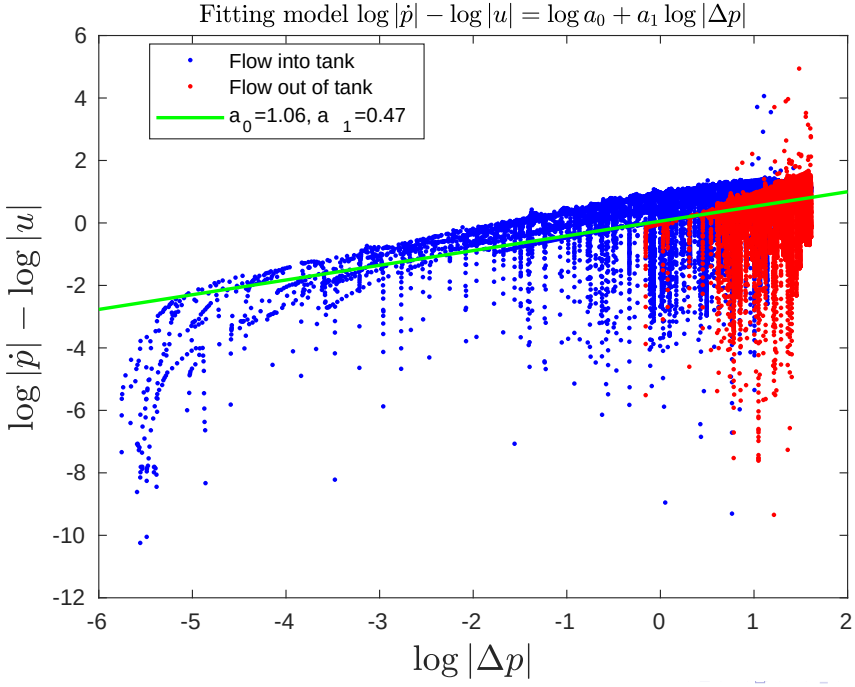
Input-output data



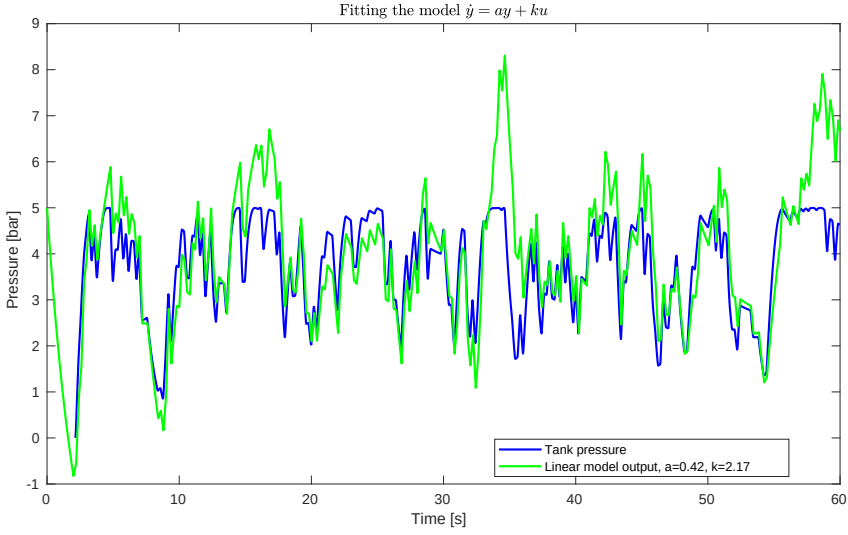
Fitting nonlinear model 1



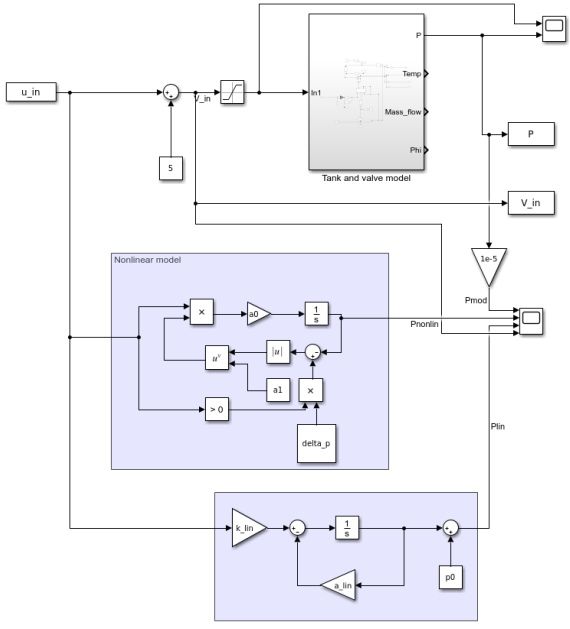
Fitting nonlinear model 2



Fitting linear model



Validation


u_in
V_in
5
In1
P
Temp
Mass_flow
Phi
Tank and valve model
P
V_in
1e-5
Pmod
Phonlin
Nonlinear model
a0
1/s
a1
> 0
delta_p
Plin
k_lin
a_lin
p0

Validation results