The dynamics of in acuator joint space is written as

$$M\ddot{q} + C\dot{q} + G = Au_{pm} - Kq - D\dot{q} + \Delta$$

$$\dot{pm}_i = \alpha_i pm_i + \beta_i pd_i$$

where

$$q = [\theta_1, l_1, \theta_2, l_2]^T, u_{pm} = [\tau_{y1}, f_{z1}, \tau_{y2}, f_{z2}]^T, diag(A) = [a_1, a_2, a_3, a_4], diag(K) = [k_1, k_2, k_3, k_4], diag(D) = [d_1, d_2, d_3, d_4]$$

Δ contains all unmodeled dynamics.

For segment i

$$\theta_i = (Encoder_{i1} - Encoder_{i2})/0.04, l_i = (Encoder_{i1} - Encoder_{i2})/2$$

$$\tau_{yi} = pd_{i1} - pd_{i2}, f_{zi} = pd_{i1} + pd_{i2} + pd_{i3}$$

Updates

$$\tau_{yi} = pm_{i1} - pm_{i2}, f_{zi} = pm_{i1} + pm_{i2} + pm_{i3}$$

Least-square

We set $y = M\ddot{q} + C\dot{q} + G$, then $y_i = a_i u_i - k_i q_i - d_i \dot{q}_i$ and apply 0-order state space model to find the parameter

The b_θ variable is corrected and calculated as $b_\theta = \frac{lc_i}{\theta_i} tan(\frac{\theta_i}{2})$.

Filter Updates:

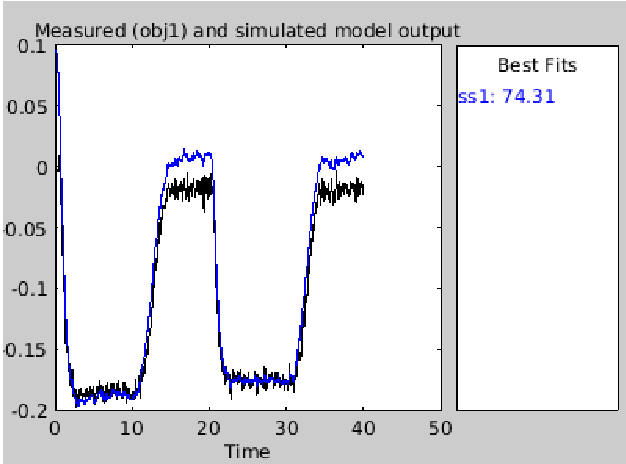
1. Wire encoder use 10pts moving average filter with 1200 sps
2. Recorded data improved to 60Hz from 30Hz
3. Vel and Acc use 10pts moving average filter for post-processing

Simluation results and observations

- **For pure simulation, x1,x3,x4 are good while x2 is not accurate**
- **For acctual parameters, all simulations are bad since we expect all positive numbers**
- **Confirmed the previous statement with linear regressor y = X*parameters**

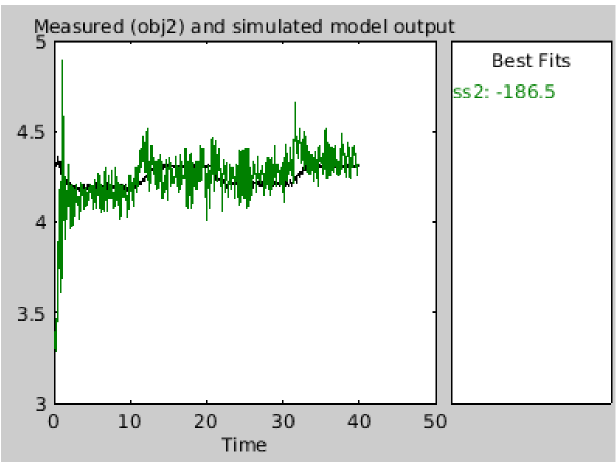
Guessings and todos:

- **Remvoing the D term by running quasi-static exp then use quasi case k to find d. (Not sure if this is a good idea since it might overfitting)**
- **Formulate the sysid as a linear greybox problem. However, all terms are coupled so we cannot id them one by one. Running all in one failed in previous nonlinear case.**



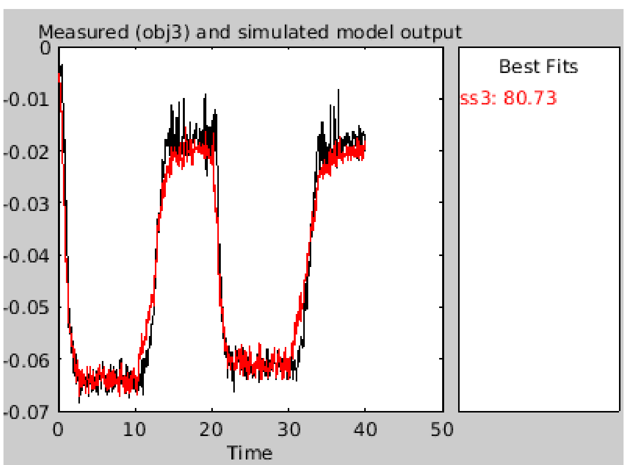

```
ss1 =
  Static state-space model: y(t) = D u(t) + e(t)

  D =
               u1         u2         u3
   y1   -0.002523    -0.4197    0.04076
```



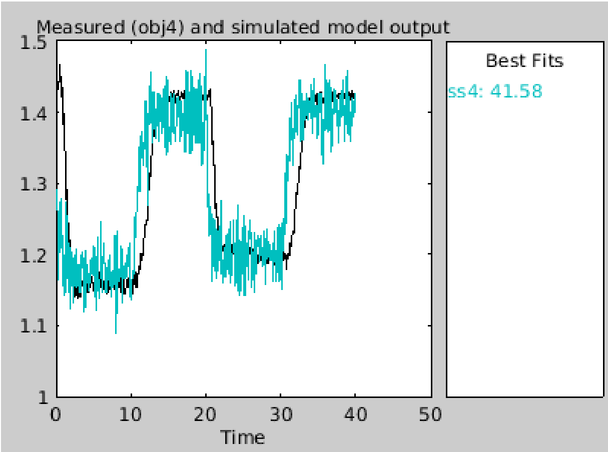

```
ss2 =
  Static state-space model: y(t) = D u(t) + e(t)

  D =
             u1         u2         u3
   y1  -0.04952      47.26      34.57
```




```
ss3 =
  Static state-space model: y(t) = D u(t) + e(t)

  D =
               u1         u2         u3
   y1  -0.001979    -0.1049    0.02027
```




```
ss4 =
  Static state-space model: y(t) = D u(t) + e(t)

  D =
              u1        u2        u3
   y1  -0.02839     12.86     8.761
```