Lecture 7: Experiment 6
EE380 (Control Systems)

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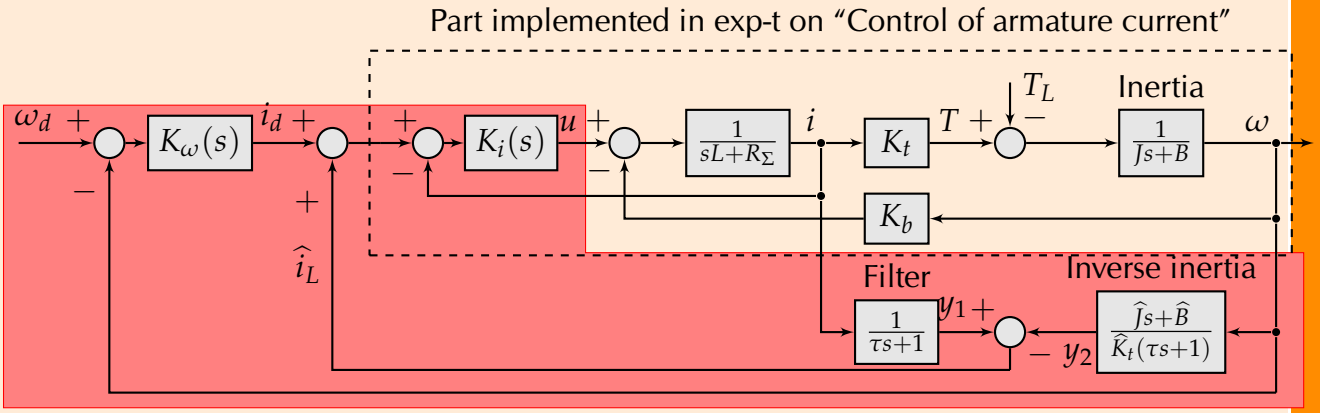
Contents

Outline of the experiment

- Build two DOF controller with disturbance observer (DOB).



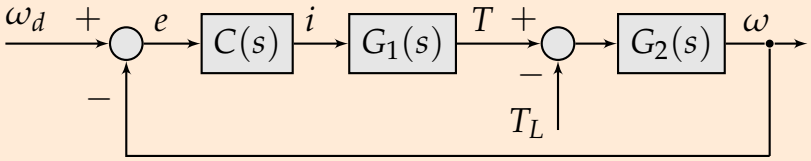
- First DOF provided by DOB in middle loop.
- Second DOF provided by speed controller $K_\omega(s)$ in outer loop.
- Shaded portion of block diagram is implemented in dsPIC.

Back
Forward
Close

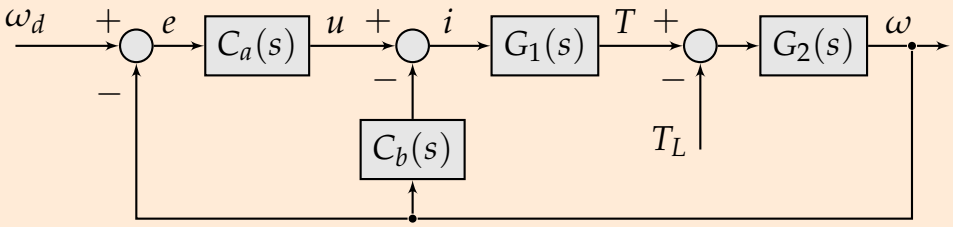
Background

Two degree of freedom control

- Single DOF controller:



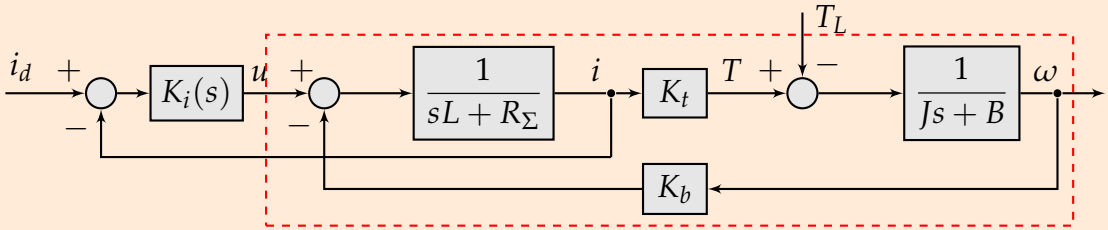
- Two DOF controller



- $C_a(s)$ provides one degree of freedom while $C_b(s)$ provides the other.
- $C_b(s)$ helps reject T_L, while $C_a(s)$ helps track ω_d.

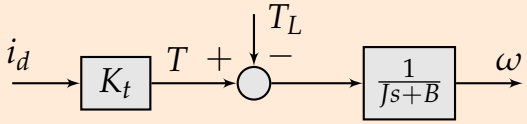
Implementation of $C_b(s)$: DOB

- Current control designed in previous experiment.



Plant: The part outside dsPIC30F4012

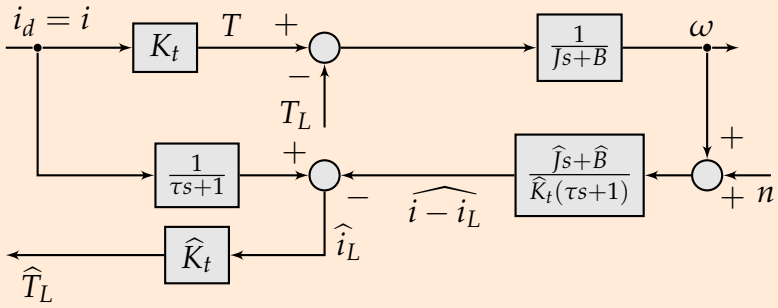
- Used $\widehat{i} \approx i_{\text{sens}}/1.8 - 1/30$. Seems a good approximation.
- Representation of motor unit with i well regulated at i_d.



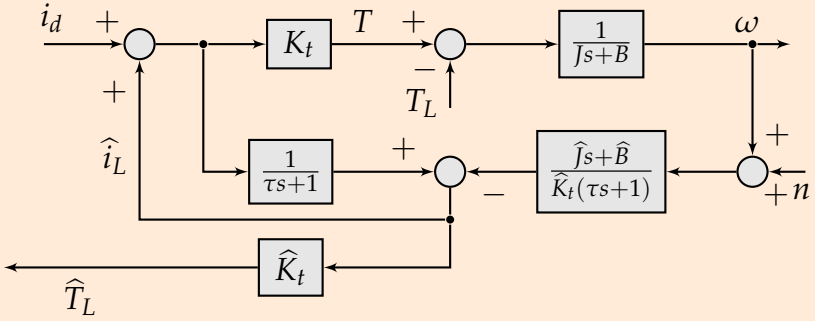
Back
Forward
Close

DOB (continued)

- Open-loop DOB to estimate T_L:



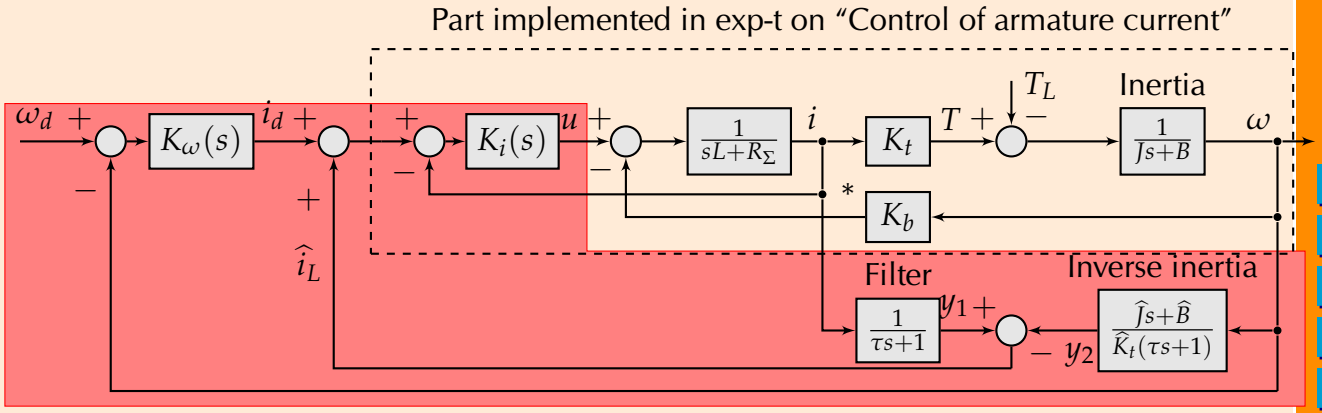
- Purpose of $1/(\tau s+1)$: ☐ to make inversion of $\frac{1}{Js+B}$ practically possible, ☐ to improve disturbance rejection.
- Closed-loop DOB to estimate T_L:



Back
Forward
Close

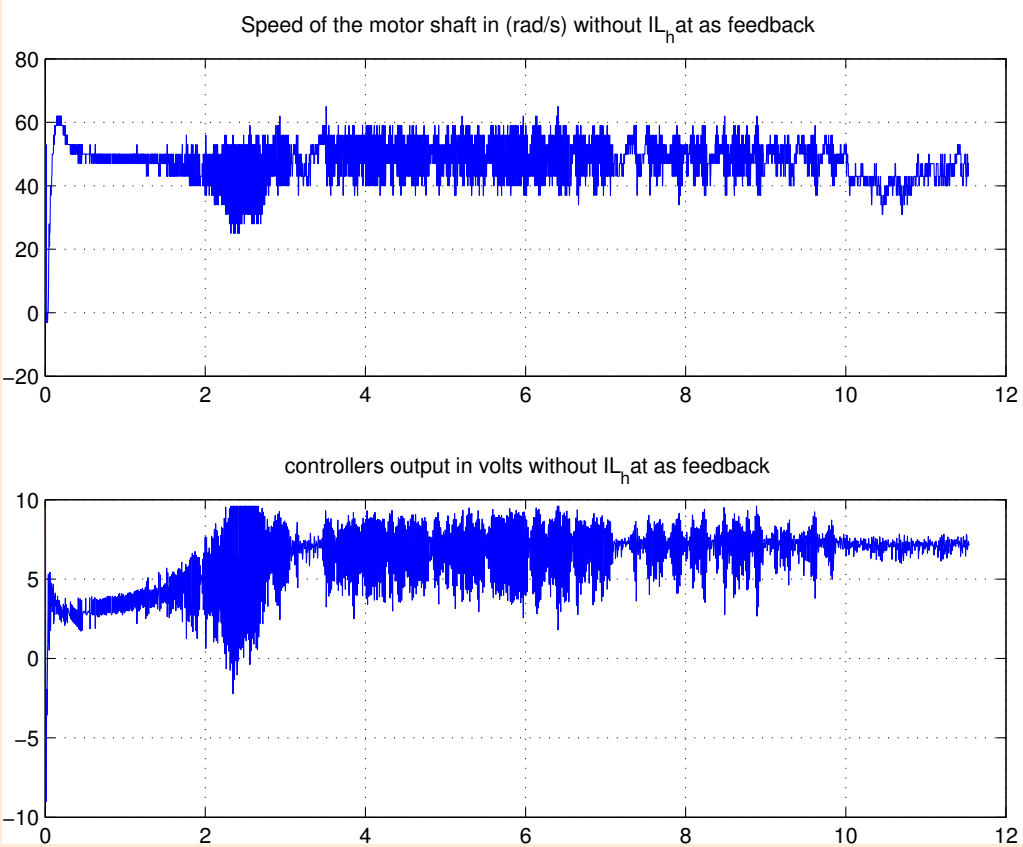
Simulink demo

- Larger the τ, poorer the disturbance rejection.
- Trade-off with τ: dist. rej. versus noise rej.
- Effect of noise.
- Effect of breaking feedback of $\widehat{i}_L$.
- Effect of moving node * to after filter.



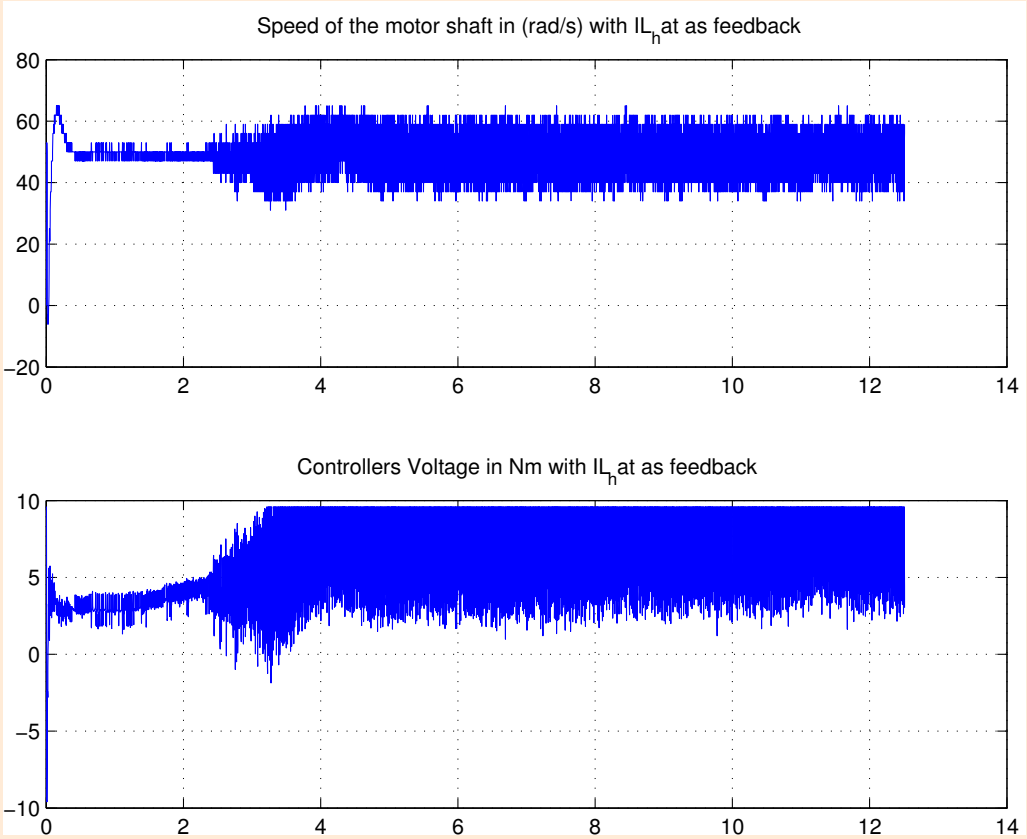
Back
Forward
Close

Practical results: PS at 12 V



Back
Forward
Close

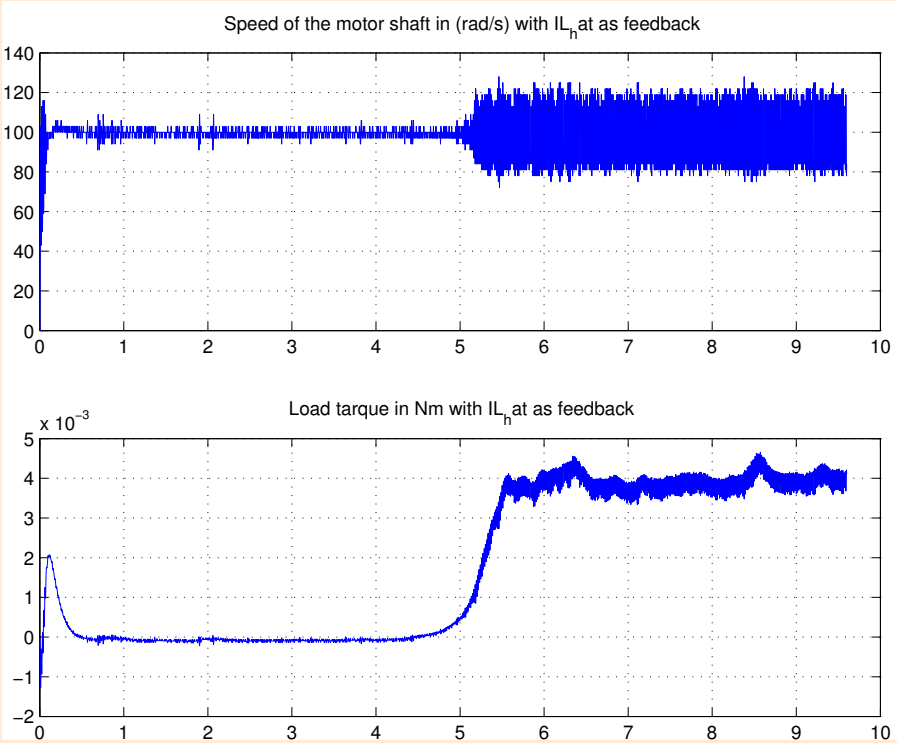
- But u is saturating.



- So, work with power supply providing 15 V to H-bridge.

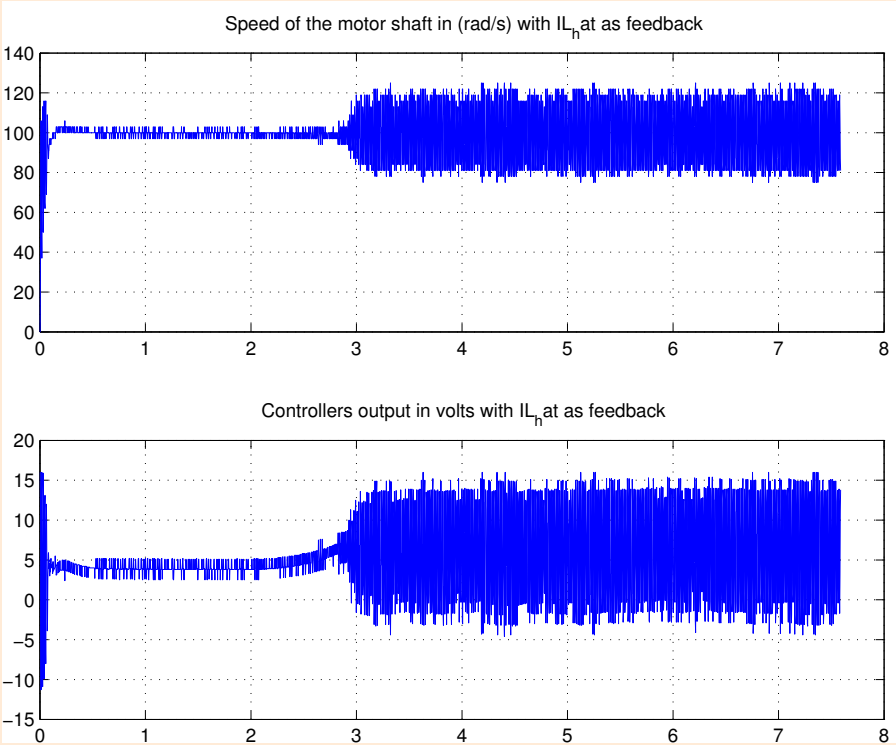
Back
Forward
Close

Practical results: PS at 20 V & using string



- Note that $\widehat{T}_L \approx 0.004$ Nm.

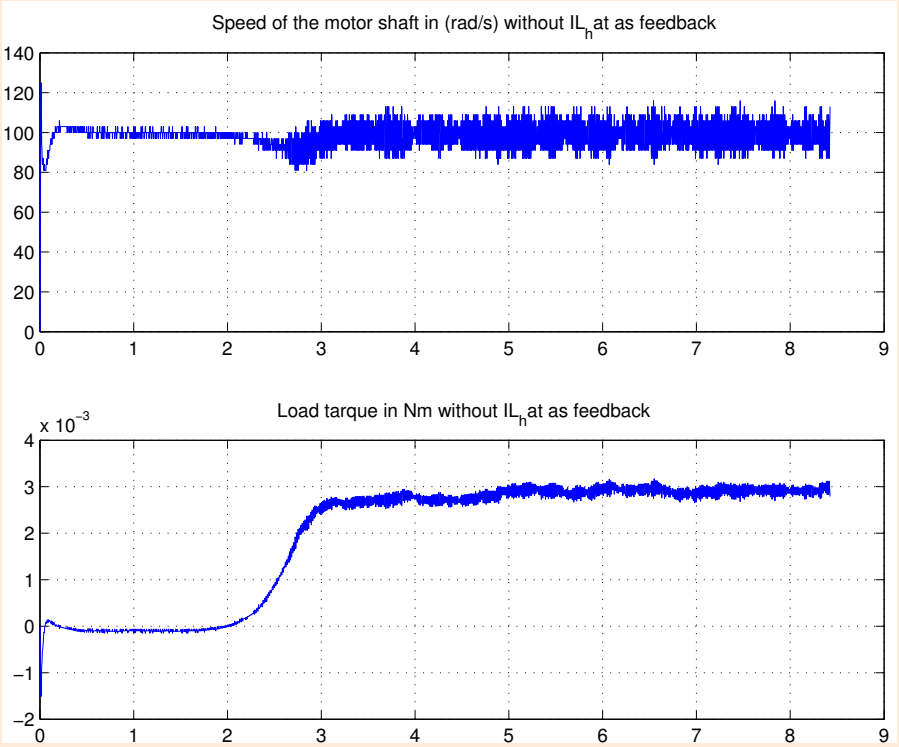
Back
Forward
Close



- Note that u is almost reaching 20 V, not saturating. Good!
- But, ω deviates 20 rad/s from mean value after T_L appears. Bad!
- Also, details of disturbance rejection blurred.

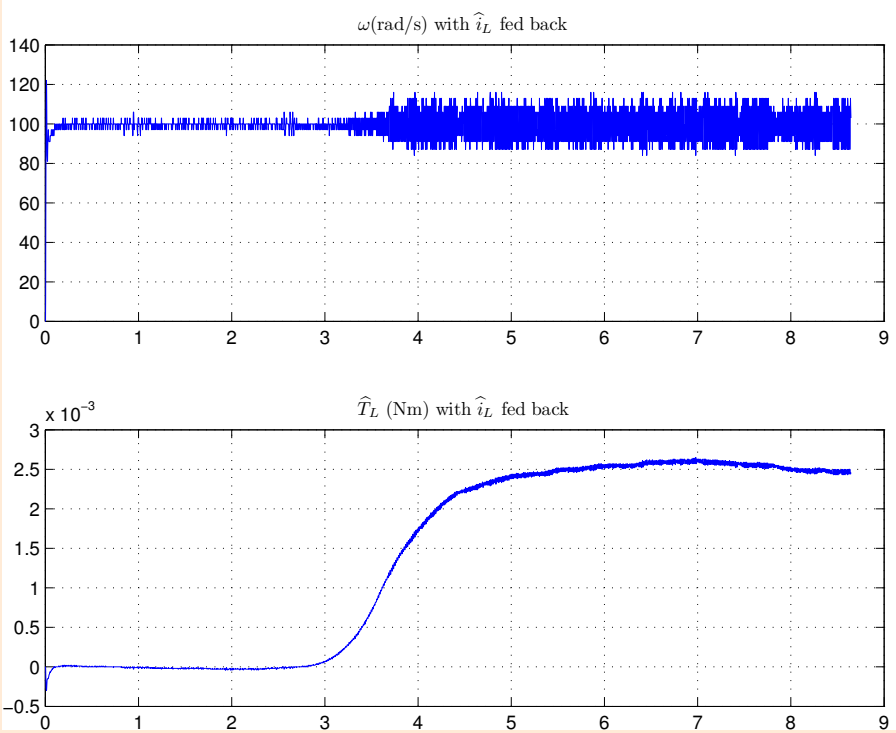
Back
Forward
Close

- Without DOB.
- But, cannot say how poorly disturbance is rejected.
- Also, $\widehat{T}_L \approx 0.003$ Nm, while with DOB it was 0.004.



Back
Forward
Close

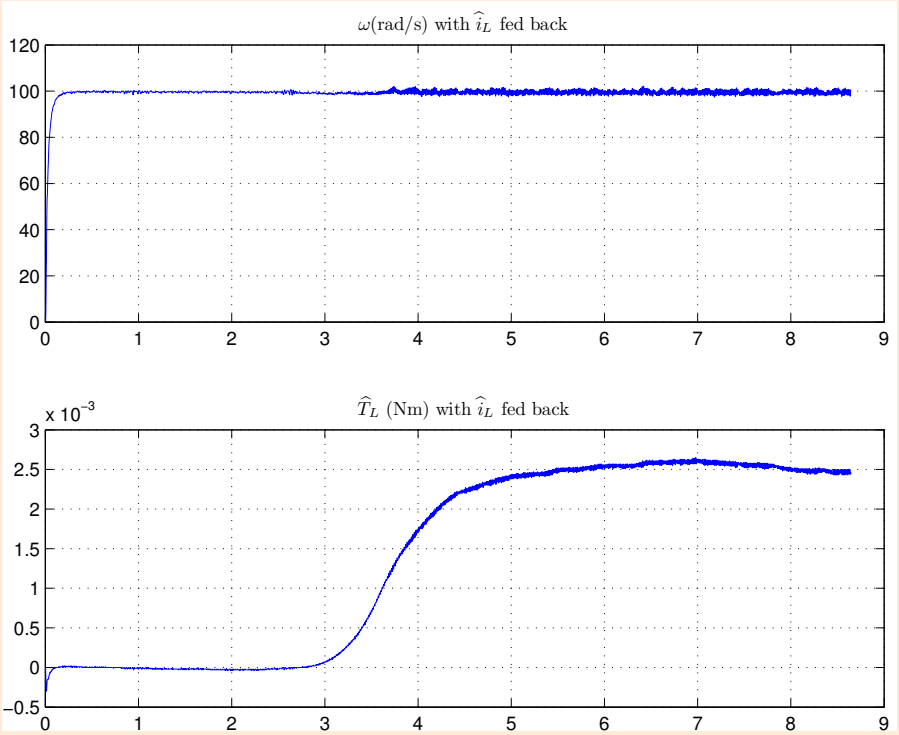
Practical results: PS at 20 V & using wire



- Deviation in ω after disturbance appears $\approx$ 10 rad/s. Improved!

Back
Forward
Close

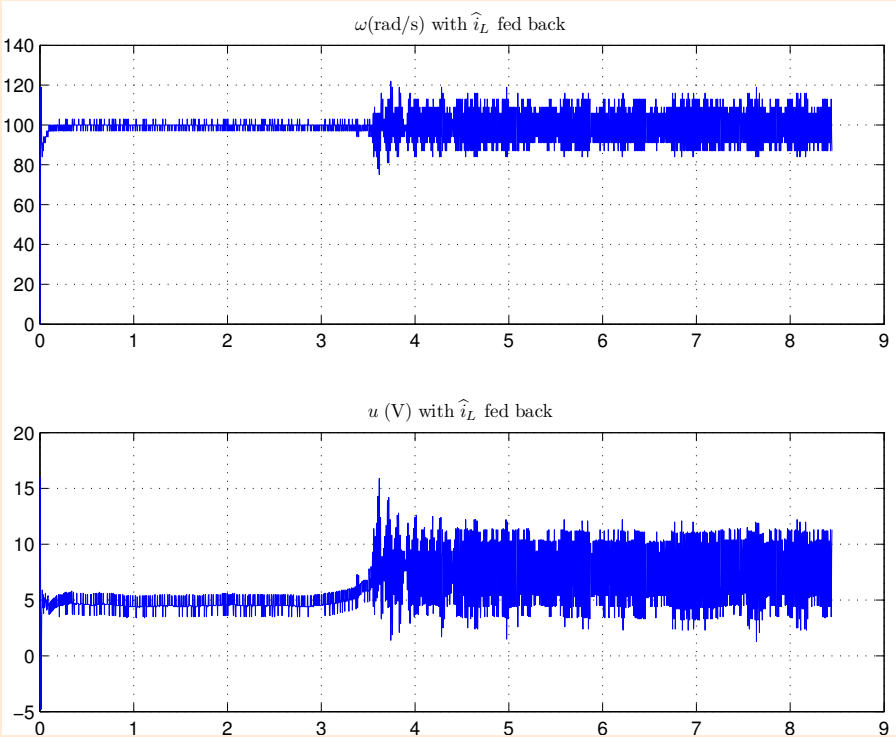
- Results of `terminal.log`, filtered.



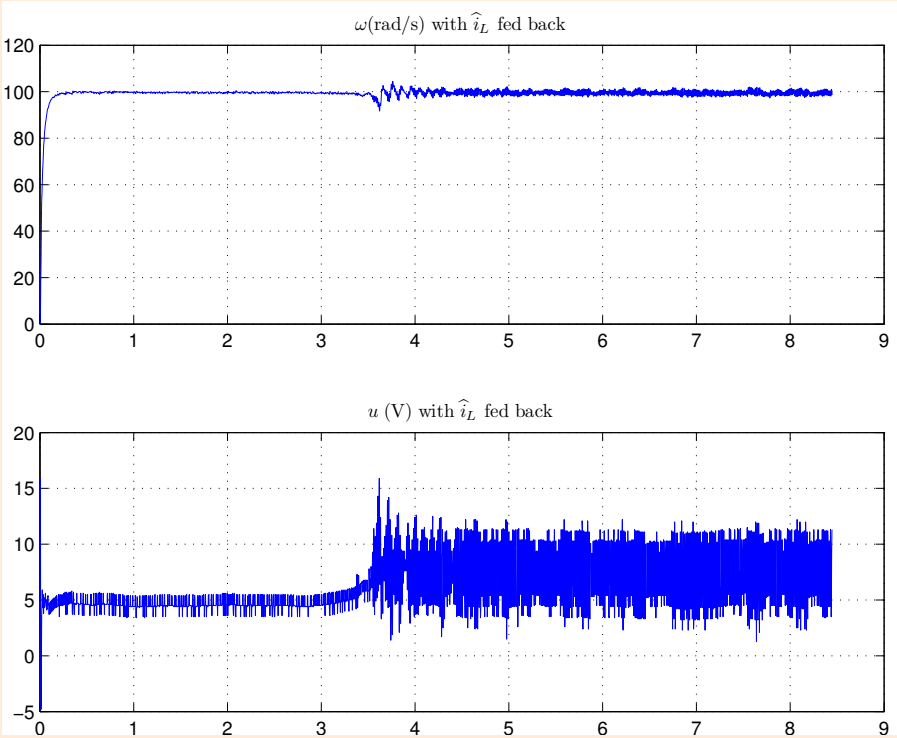
- $\widehat{T}_L \approx 0.0025$ Nm. Explanation: string was making the radius of pully larger than wire is making.

Back
Forward
Close

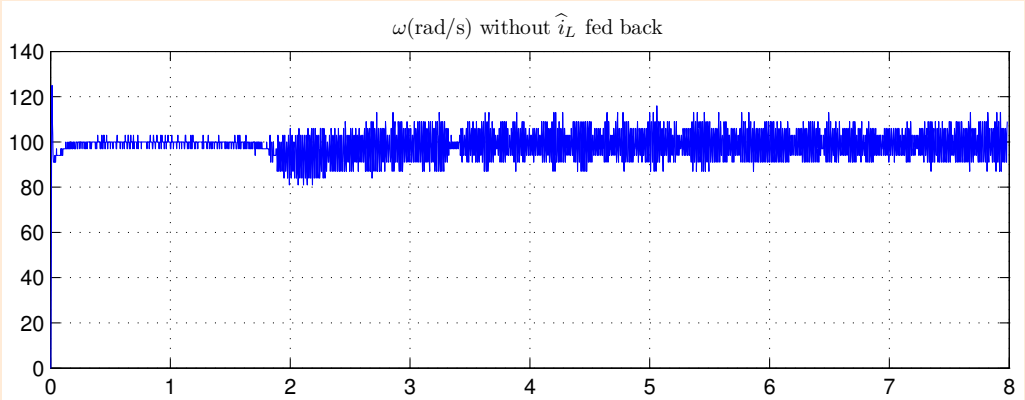
- More results with DOB.

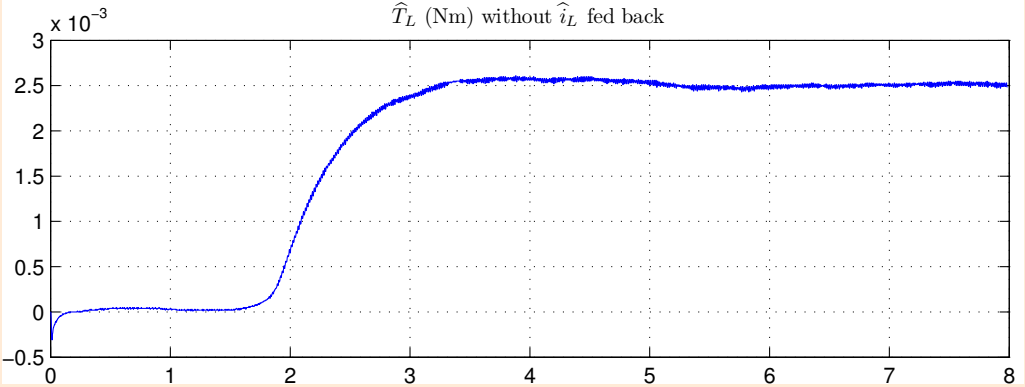


- And, filtered results of `terminal.log`.

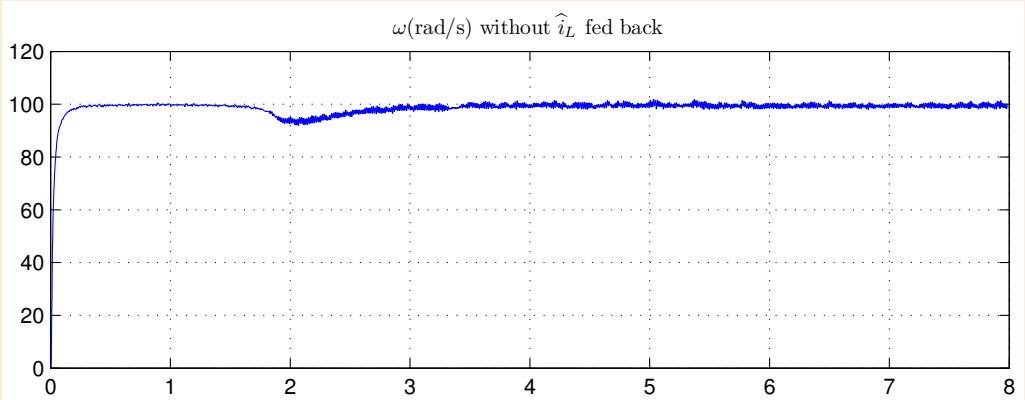


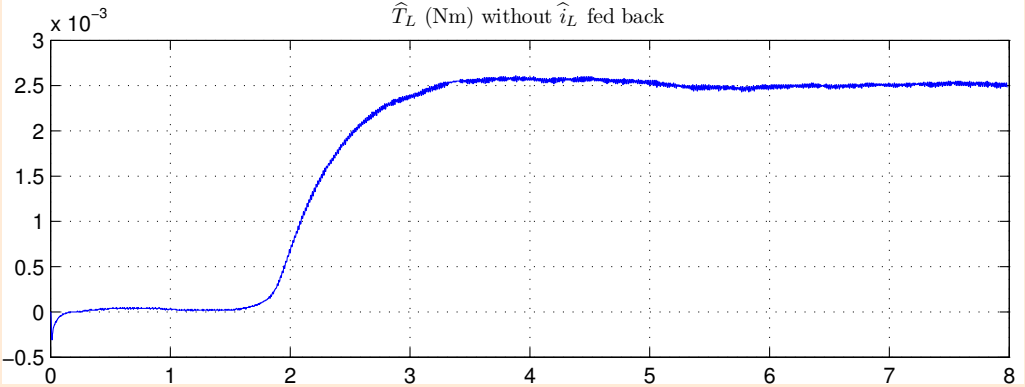
Back
Forward
Close



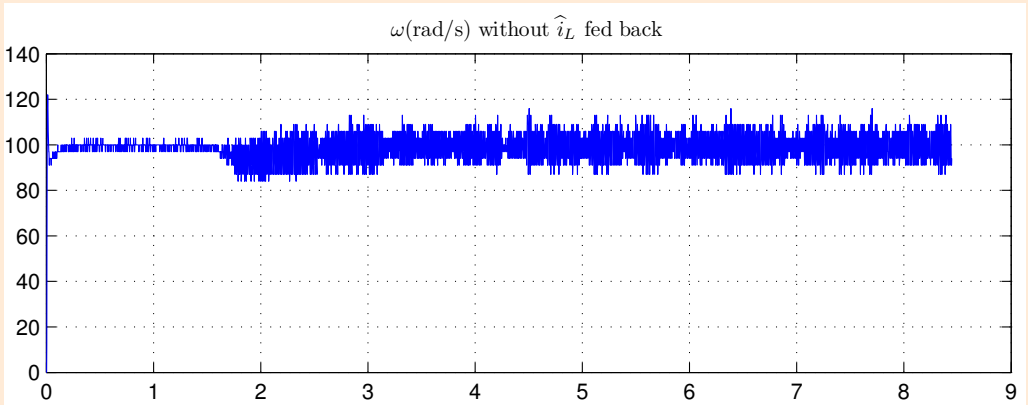


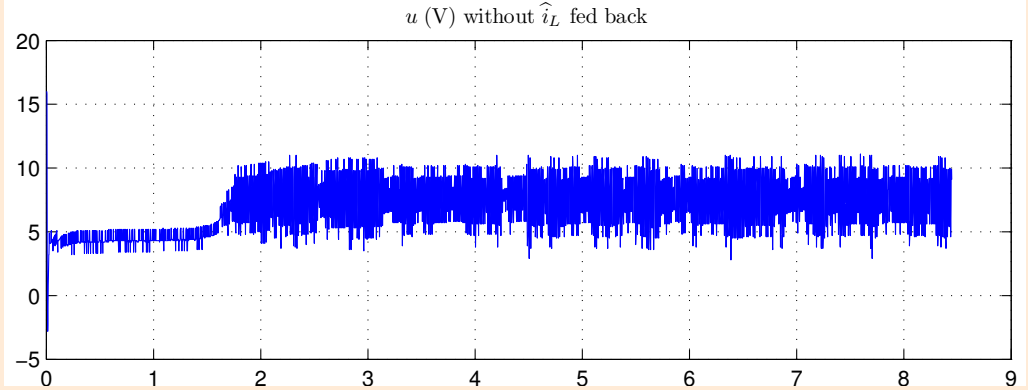
Back
Forward
Close



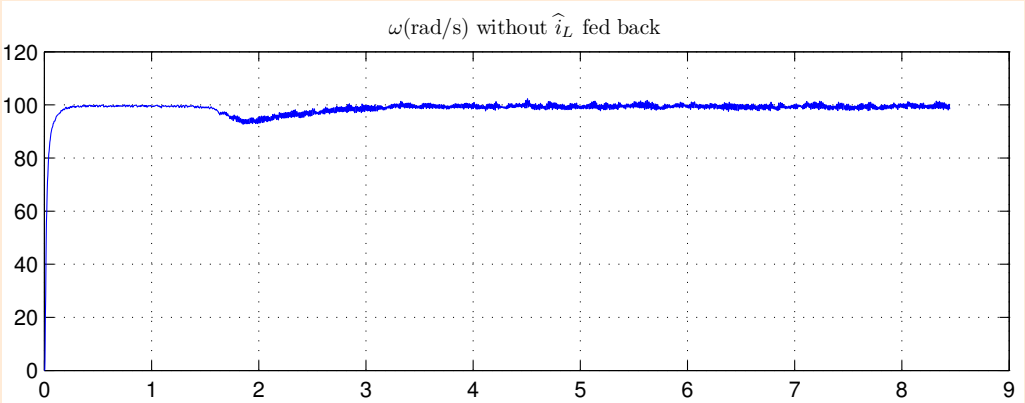


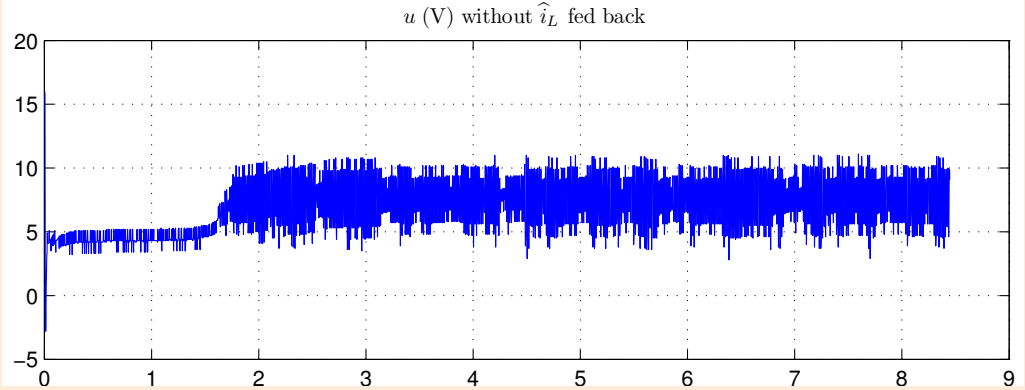
Back
Forward
Close





Back
Forward
Close





Back
Forward
Close

Homework (HW) vs. Lab work (LW)

See the lab manual.