Autonomous Navigation for Flying Robots

Lecture 4.2 : Feedback Control

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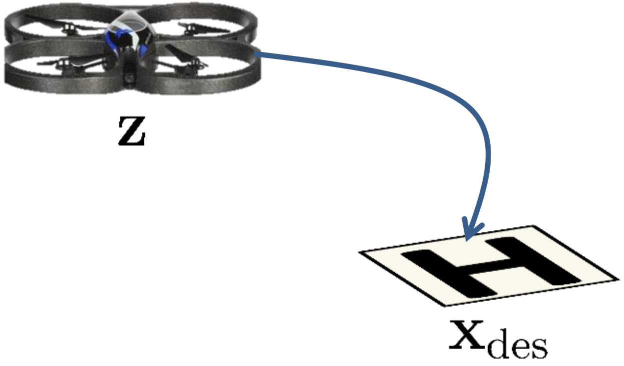
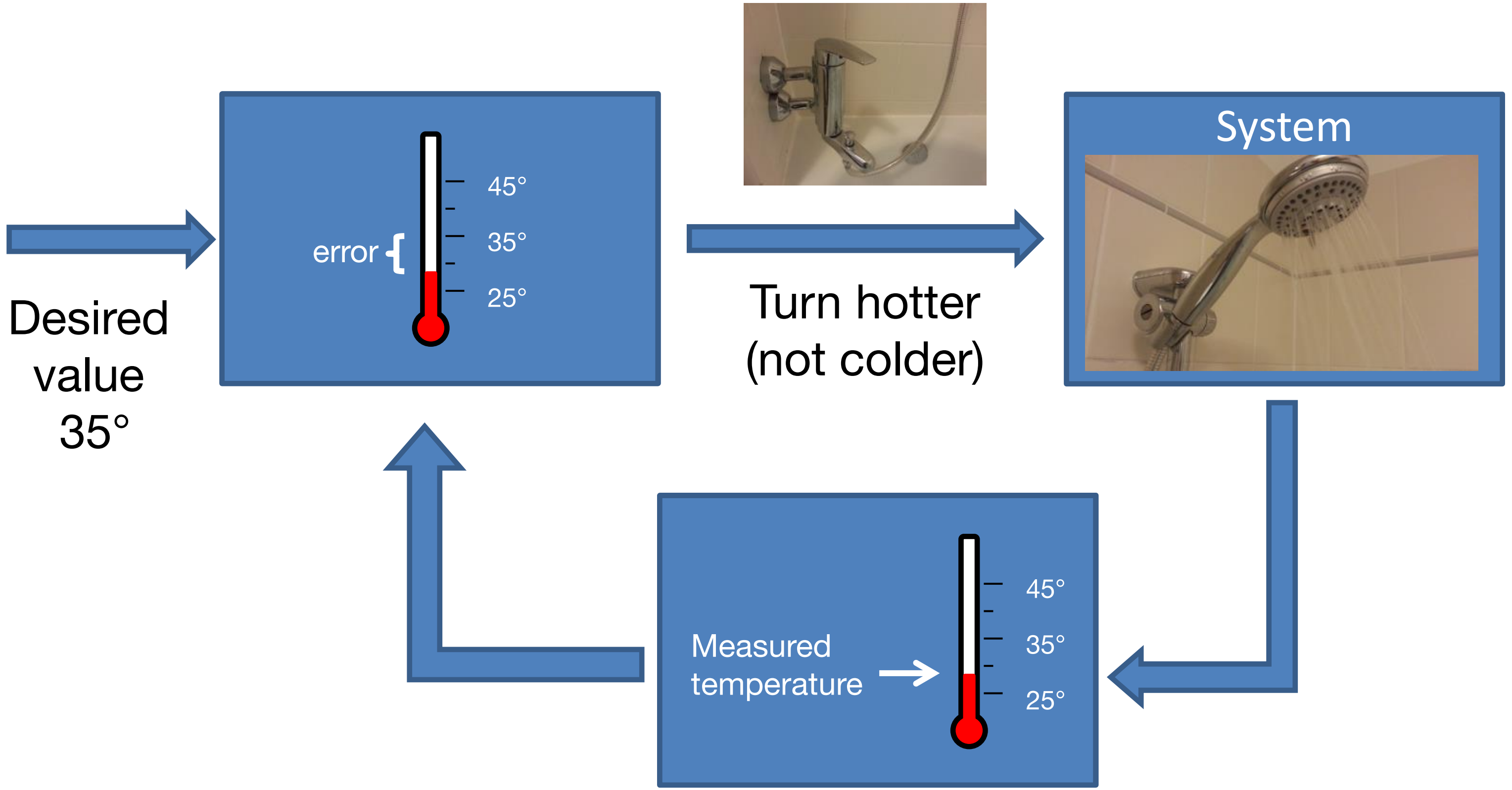
Motivation: Position Control

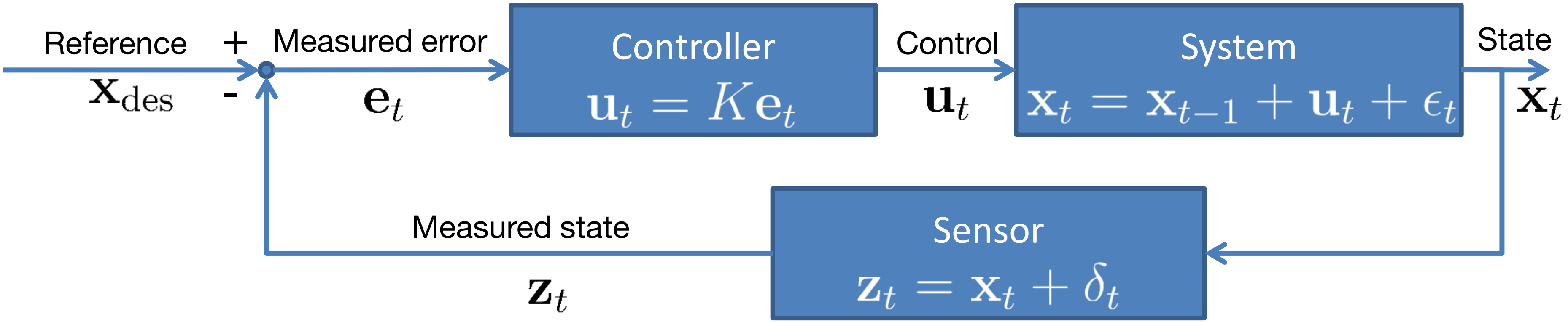
- Move the quadrotor to a desired location $\mathbf{x}_{\text{des}}$
- How can we generate a suitable control signal $\mathbf{u}$?
- Current location (observed through sensors) $\mathbf{z}$



Feedback Control – Generic Idea

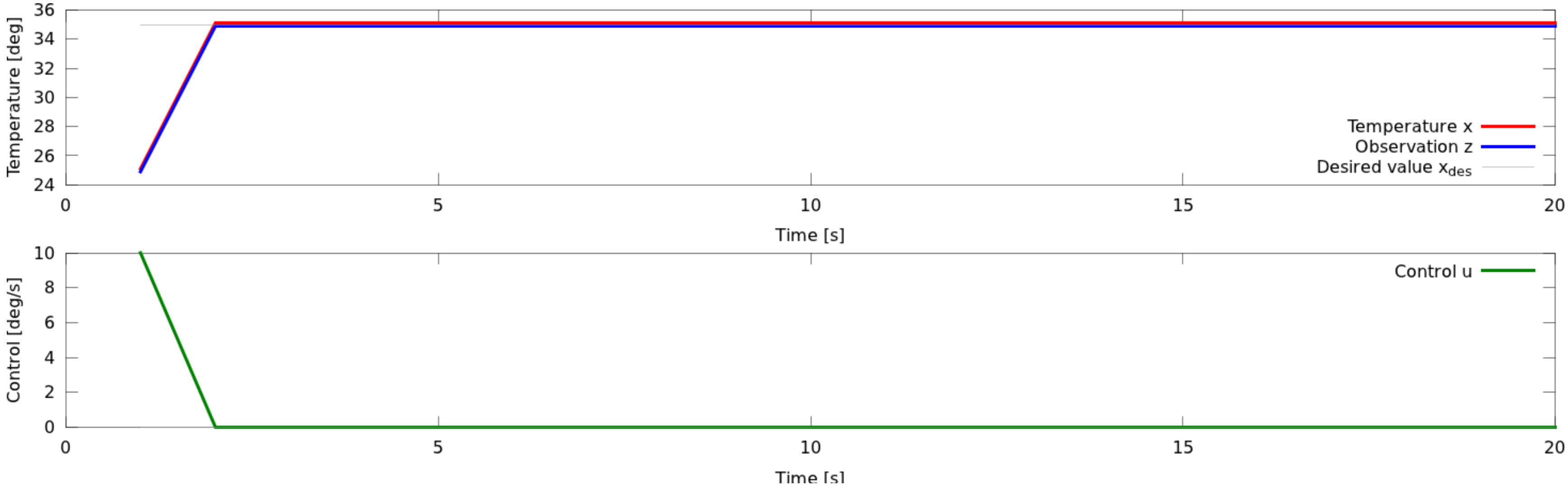


Feedback Control – Block Diagram



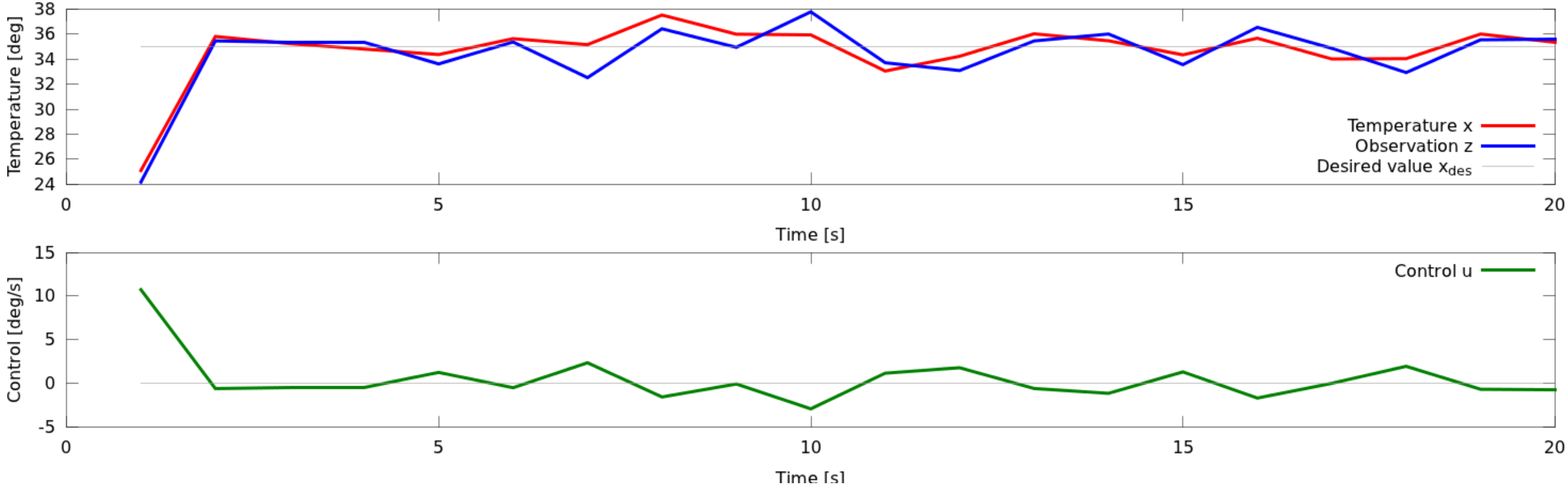
Proportional Control

- P-Control: $\mathbf{u}_t = K\mathbf{e}_t$



Effect of Noise

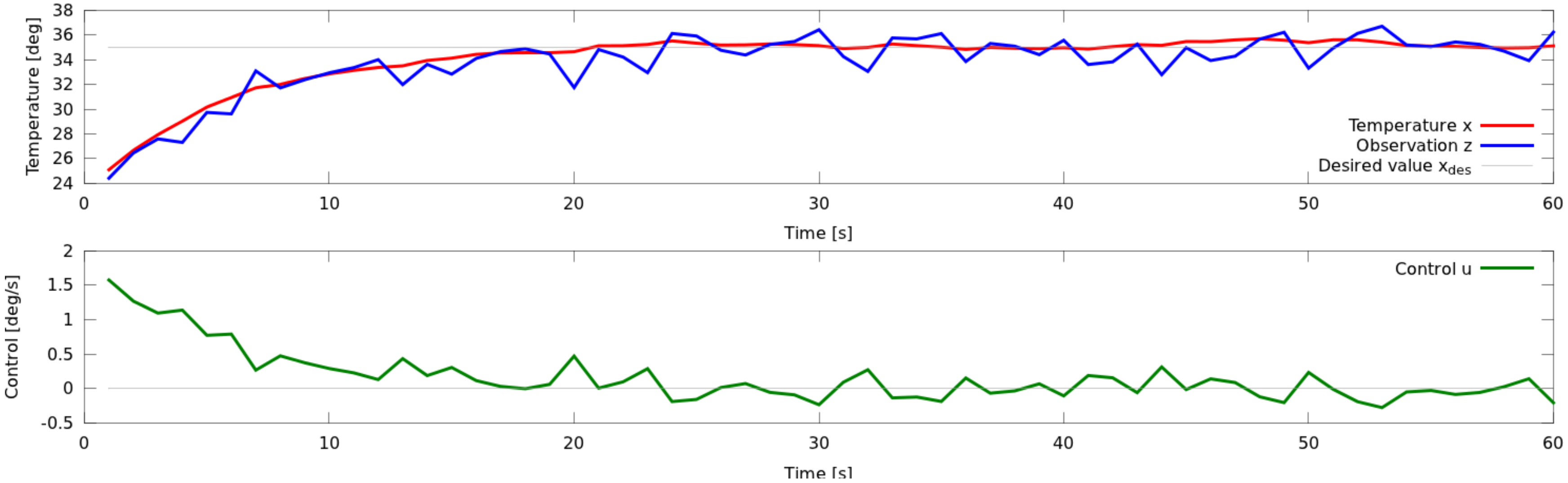
- What effect has noise in the process/measurements?



- Poor performance for K=1
- How can we fix this?

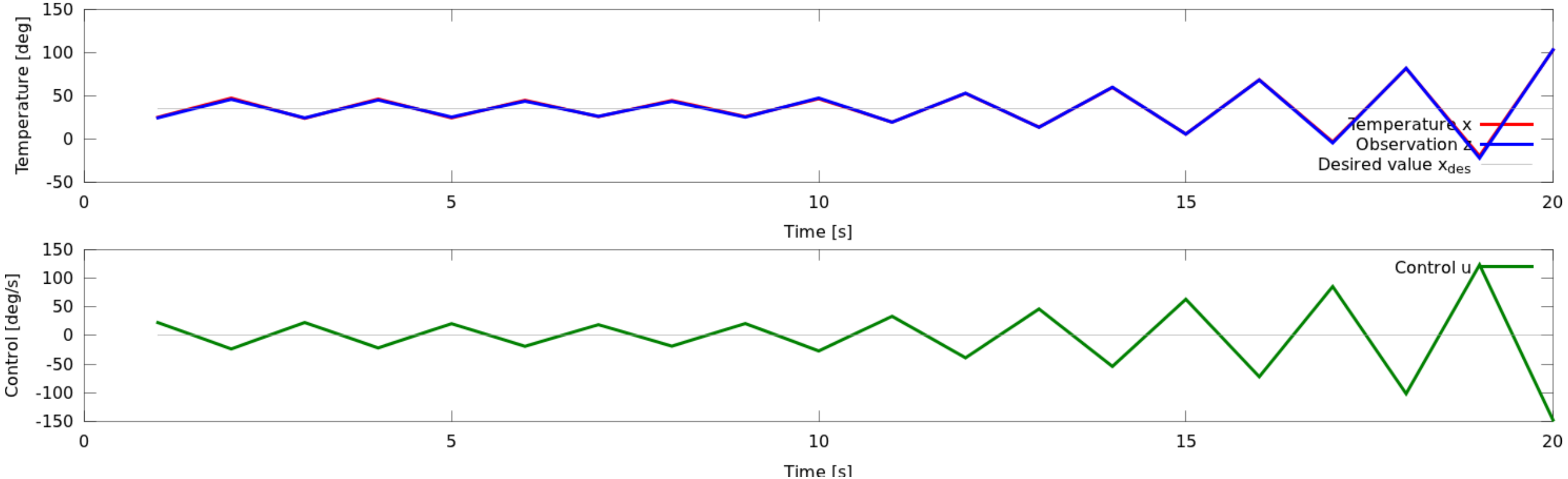
Proper Control with Noise

- Lower the gain… (K=0.15)



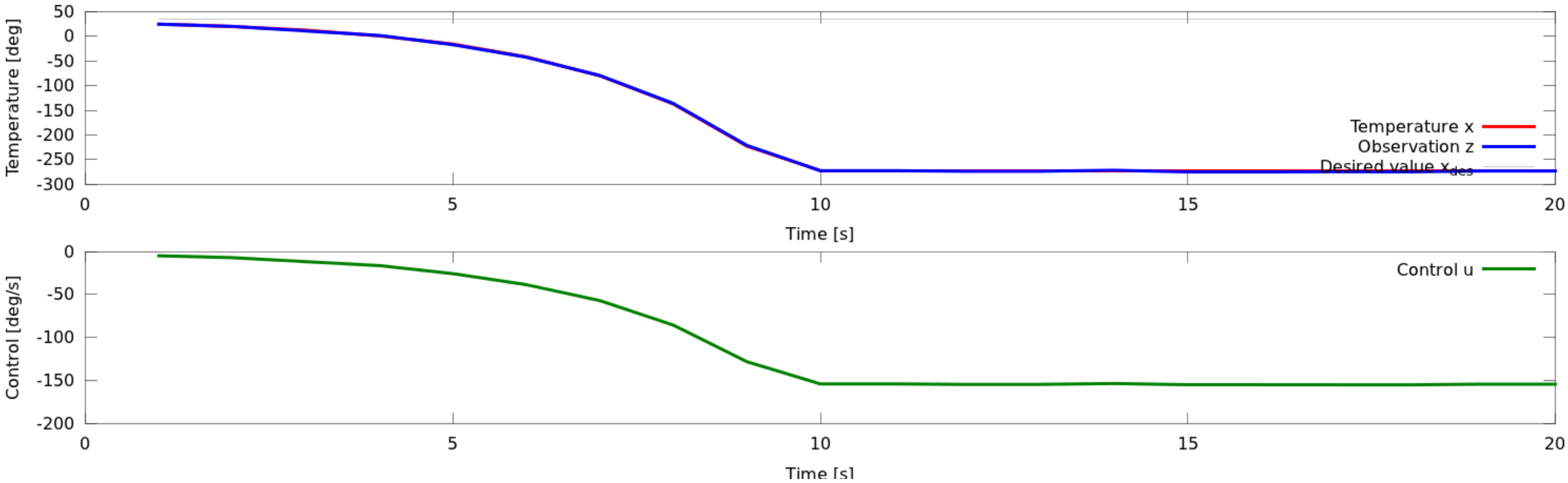
What do High Gains do?

- High gains are always problematic (K=2.15)



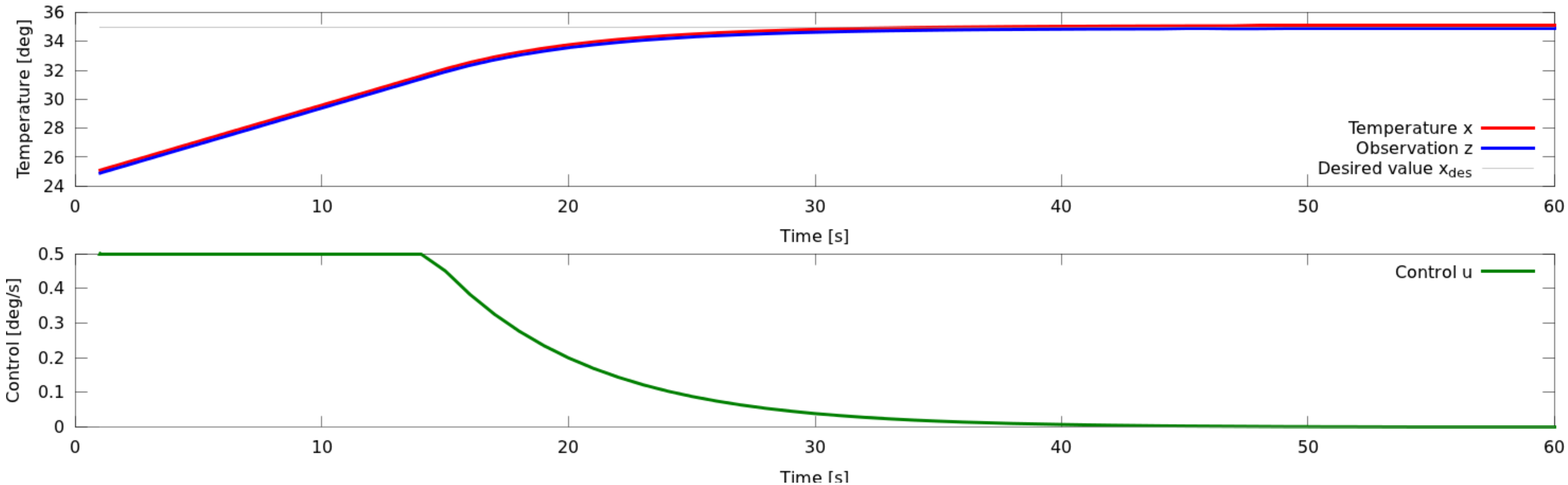
What happens if sign is messed up?

- Check K=-0.5



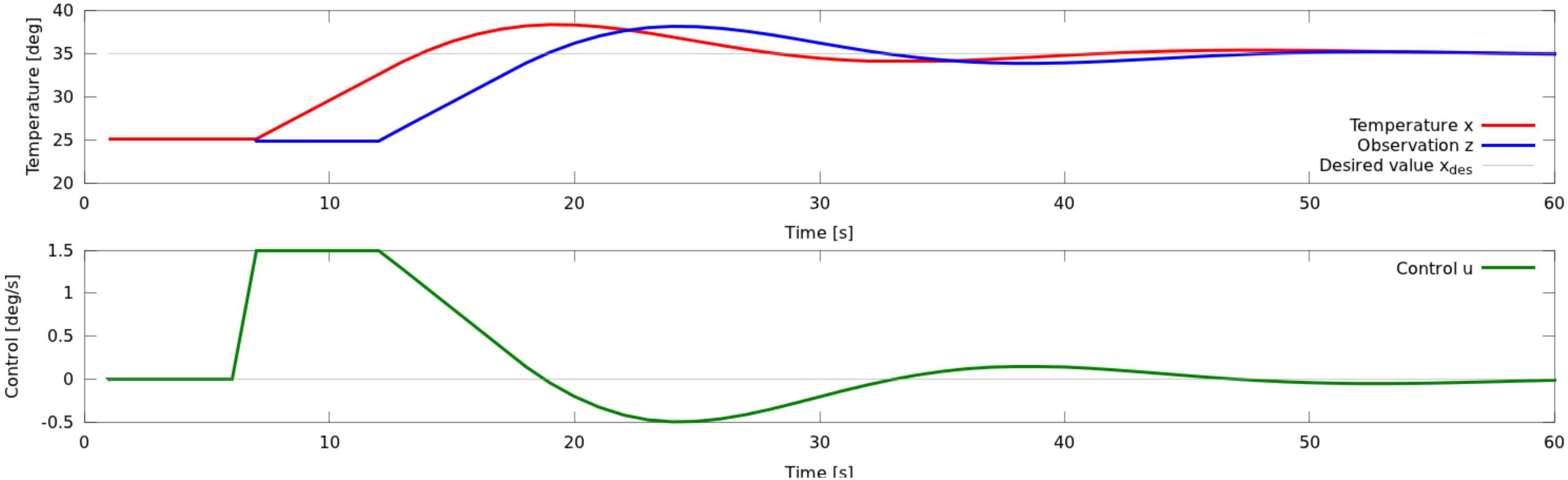
Saturation

- In practice, often the set of admissible controls u is bounded
- This is called (control) saturation



Delays

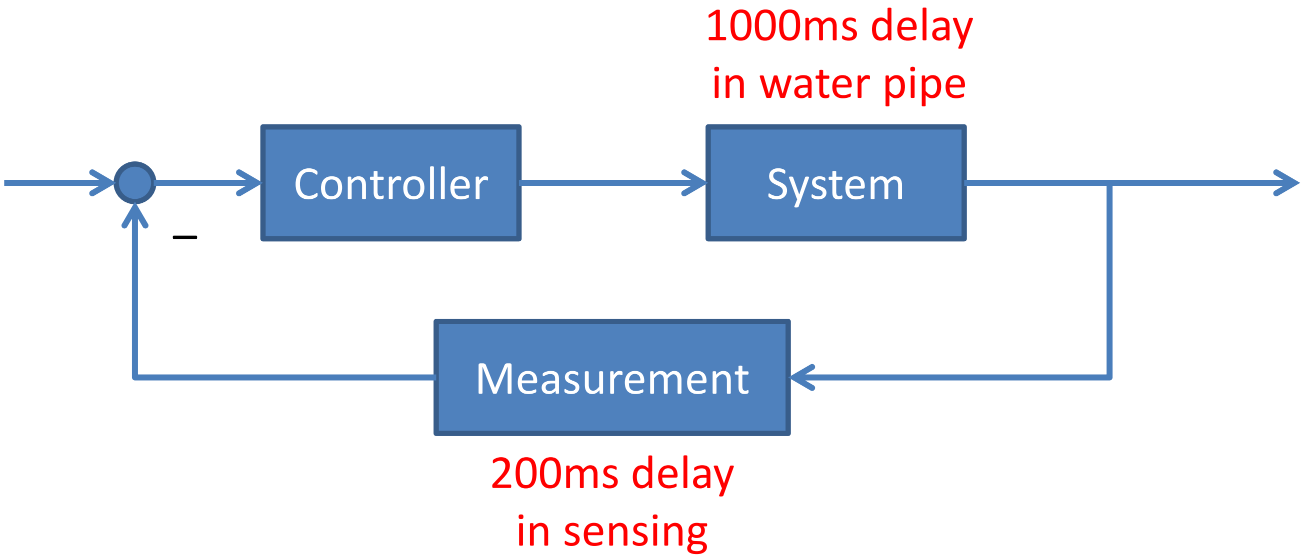
- In practice most systems have delays
- Can lead to overshoots/oscillations/de-stabilization



- One solution: lower gains (why is this bad?)

Delays

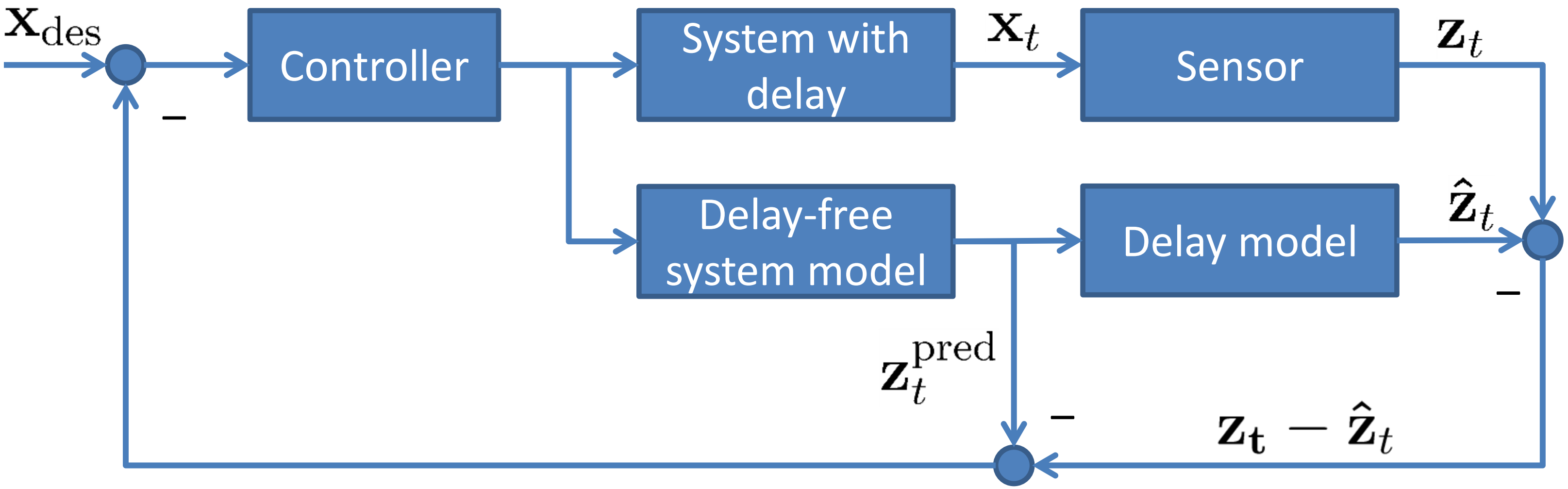
- What is the total dead time of this system?



- Can we distinguish delays in the measurement from delays in actuation?

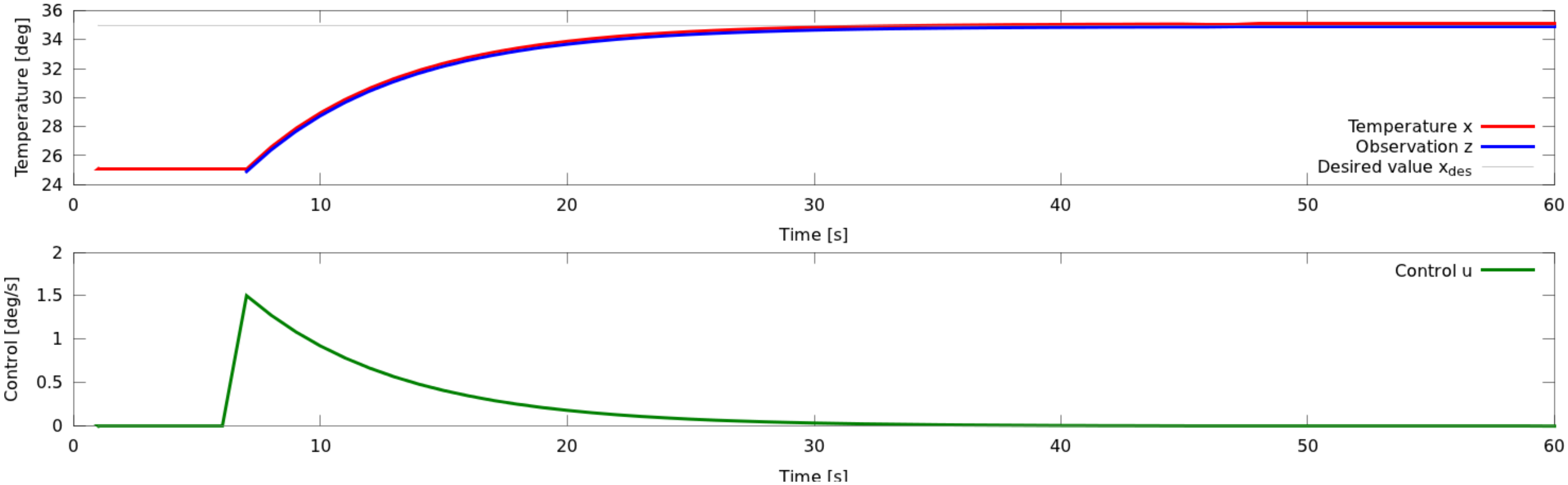
Smith Predictor

- Allows for higher gains
- Requires (accurate) system model



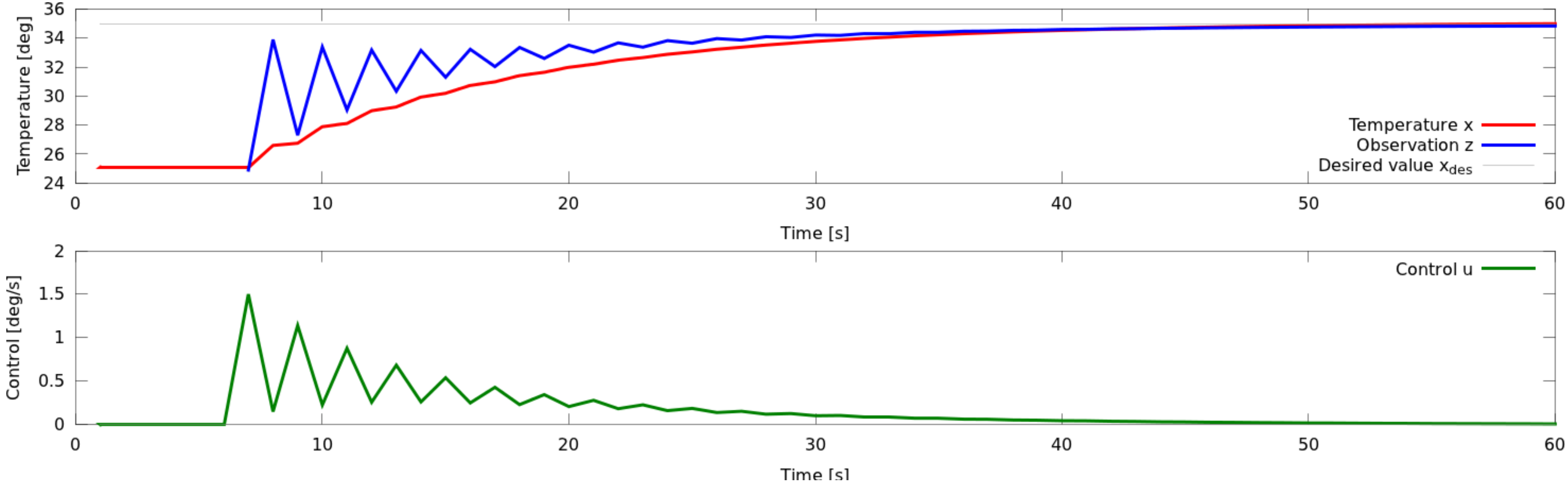
Smith Predictor

- Assumption: System model is available, 5 seconds delay
- Smith predictor results in perfect compensation
- Why is this unrealistic in practice?



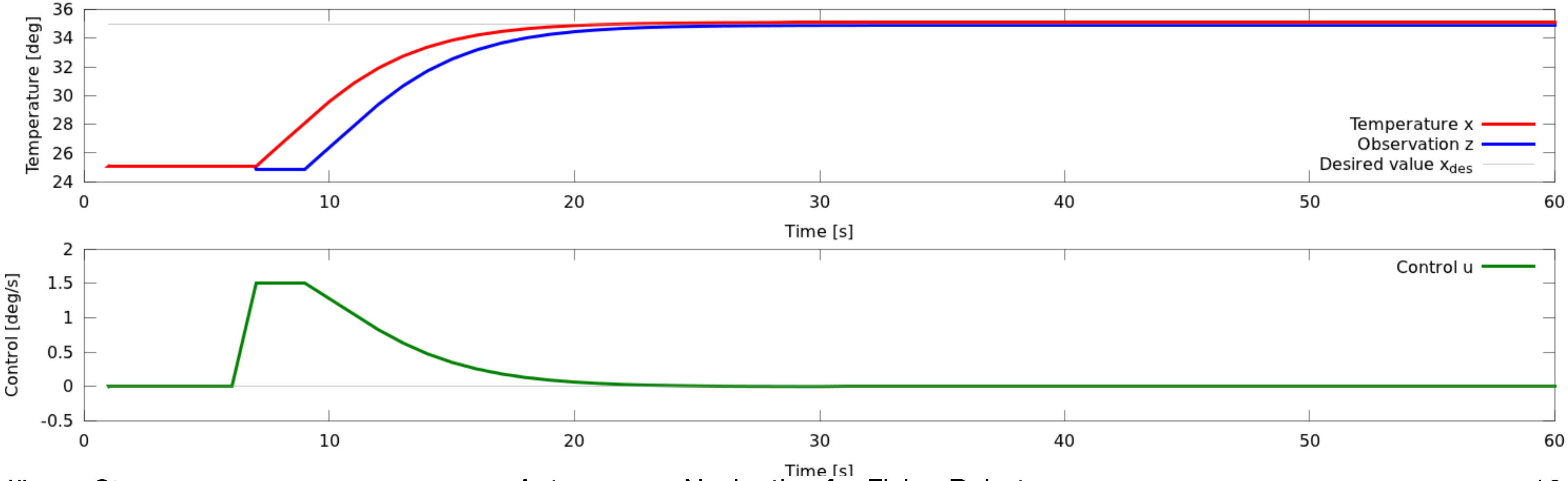
Smith Predictor

- Time delay (and system model) is often not known accurately (or changes over time)
- What happens if time delay is **overestimated**?



Smith Predictor

- Time delay (and plant model) is often not known accurately (or changes over time)
- What happens if time delay is **under**estimated?



Lessons Learned

- Control problem
- Feedback control
- Proportional control
- Delay compensation

- Next video:
  - PID control
  - Position control for quadrotors