ECE 486: Control Systems

Lecture 7A: Summary Of Control Design Issues

Key Takeaways

Models used for control design are often simplified and contain a variety of inaccuracies.

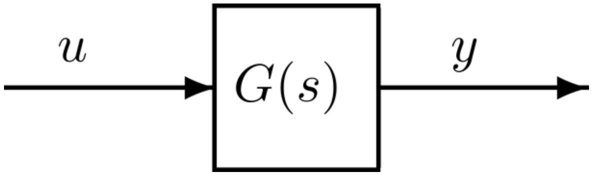
- Uncertain parameters, unmodeled dynamics, nonlinear effects, and implementation effects.

Control design involves trade-offs to satisfy many conflicting objectives.

- Stability, reference tracking, disturbance rejection, actuator effort, noise rejection, and robustness to model uncertainty.

DC Motor

DC motors are found in many applications, e.g. multicopters.

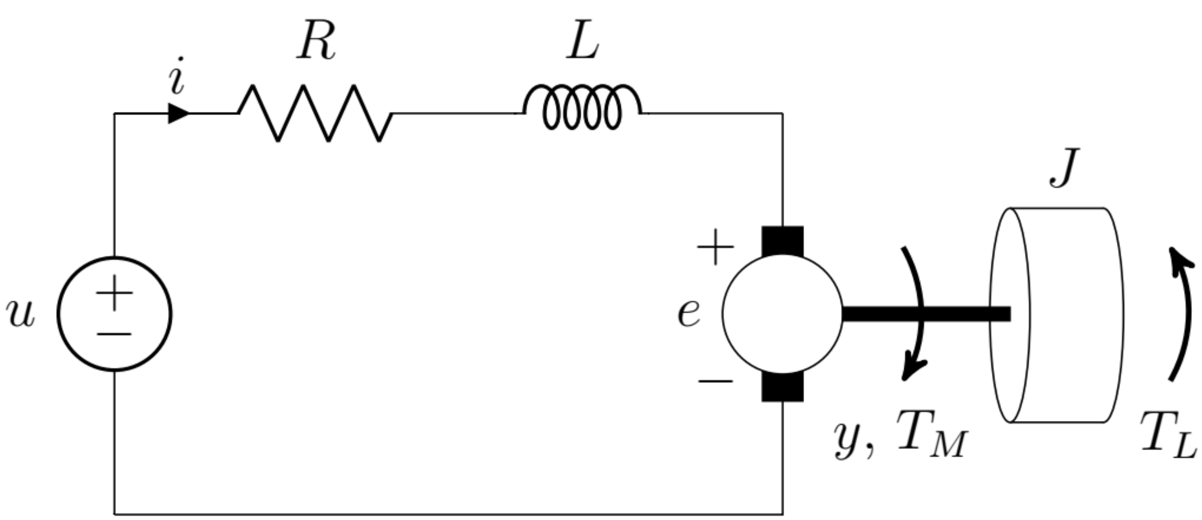


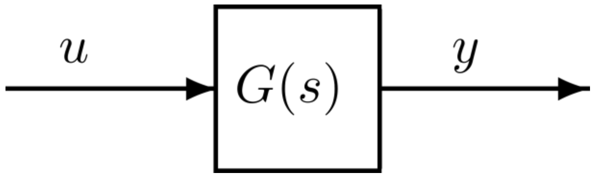
u:= Voltage (V)

y:= rotational speed (rad/sec)

Modeling the Motor Dynamics

- Our control designs will be based on low-order models.
- Modeling is an important step but is domain specific.
- The motor involves coupled electrical and mechanical (rotational inertia) dynamics.





u:= Voltage (V)

y:= rotational speed (rad/sec)

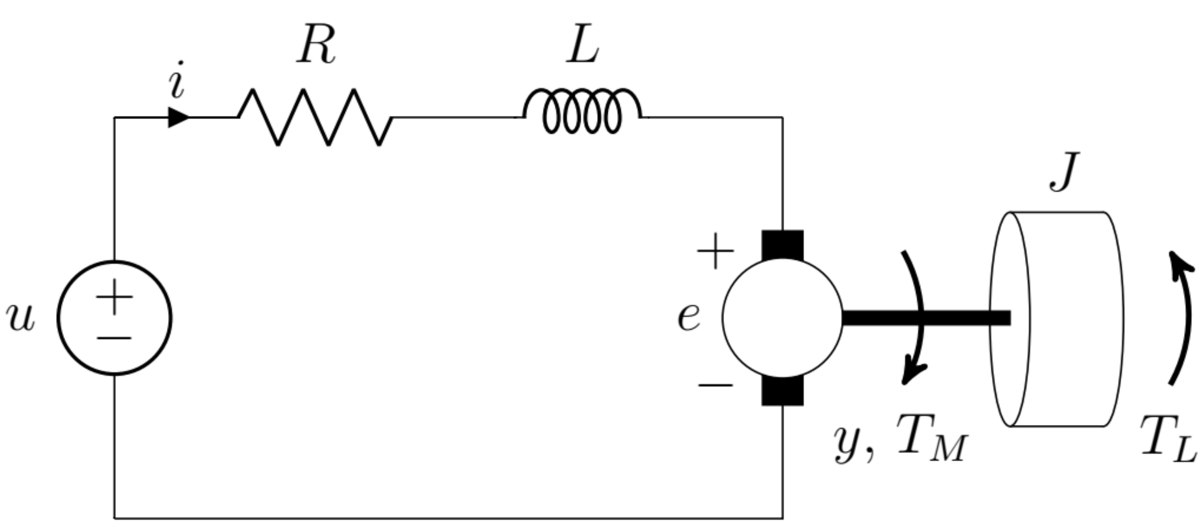
Modeling the Motor Dynamics

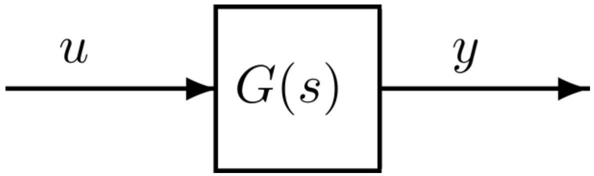
Neglecting the "fast" electrical dynamics:

$$\dot{y}(t) + a_0\, y(t) = b_0\, u(t) + b_0\, d(t)$$

$$\text{where: } \; a_0 = 0.94 \frac{1}{sec} \; \text{ and } \; b_0 = 766.8 \frac{rad}{sec^2\, V}$$

where *d (V)* models the effect of environmental disturbances.





u:= Voltage (V)

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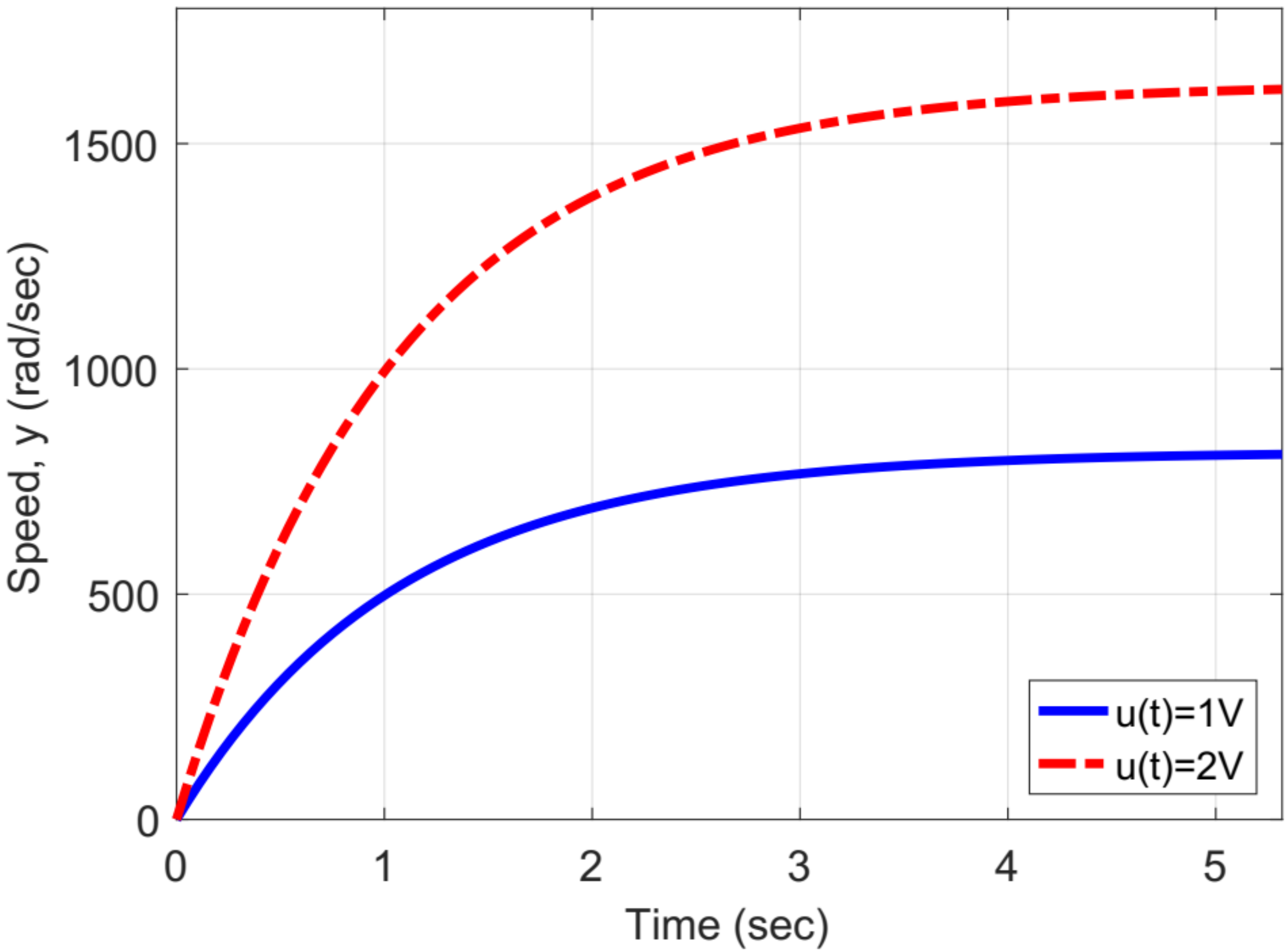
Nominal Step Responses



Transfer Function

$$G(s) = \frac{766.8}{s+0.94}$$

DC Gain

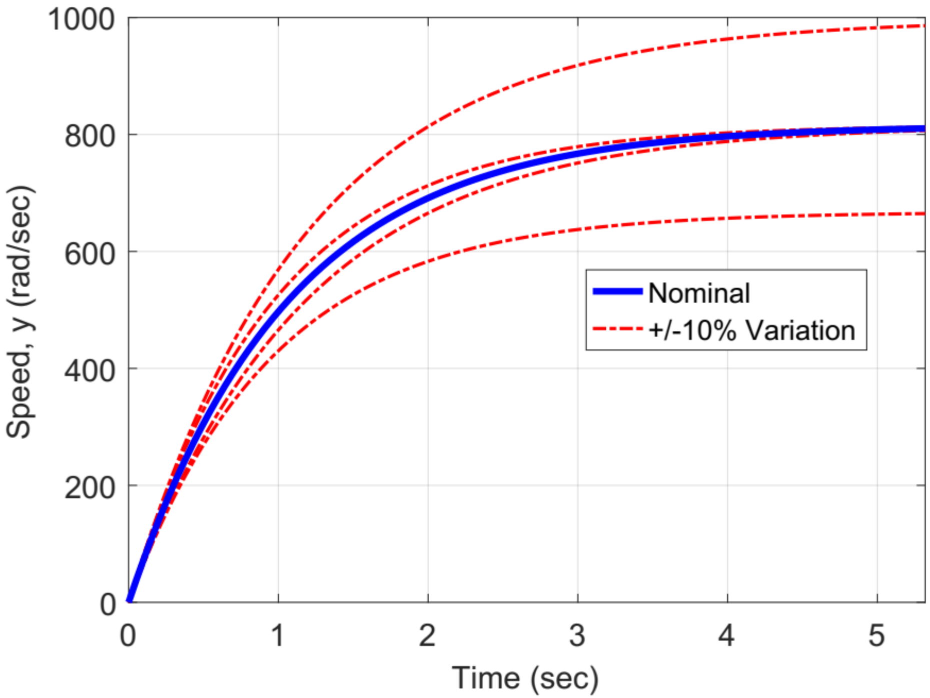
$$G(0) = 815.7 \frac{rad}{sec\,V}$$

Settling Time

$$3\tau = 3.18 sec$$

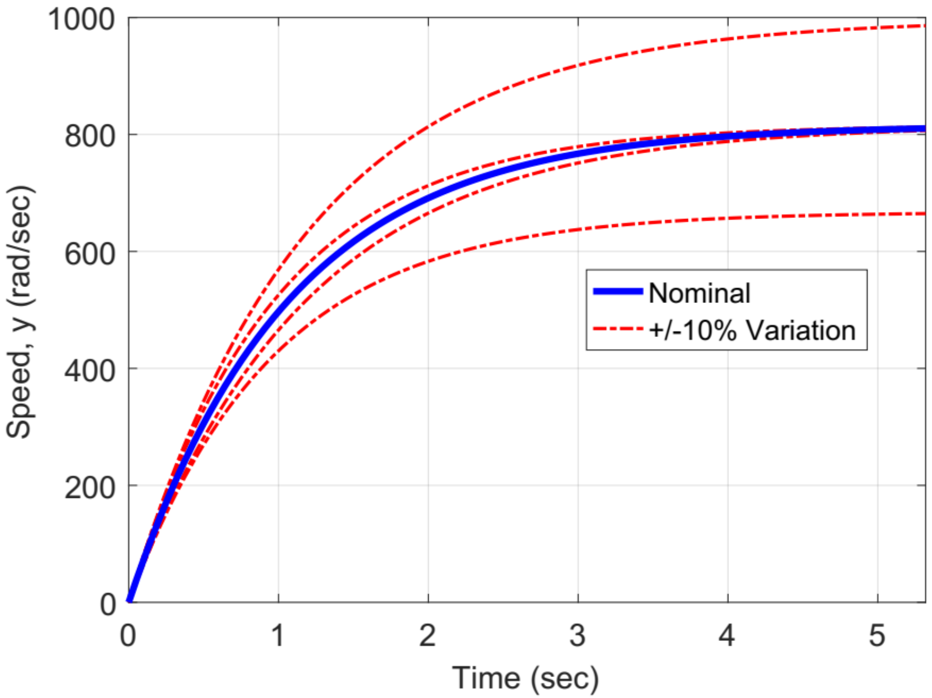
Model Simplifications and Uncertainties

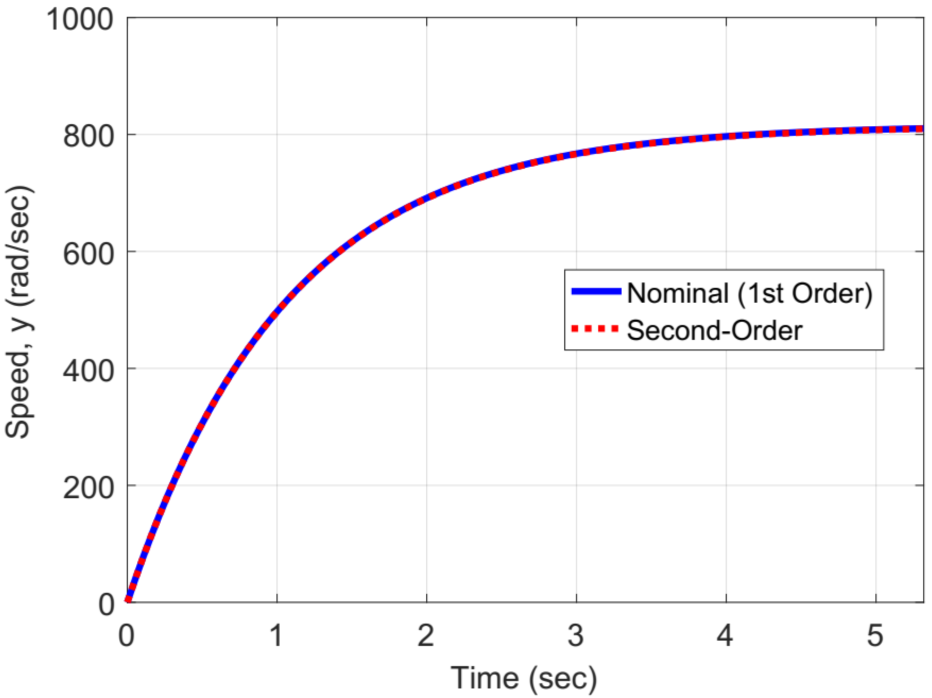
- Uncertainty in parameters (a_0, b_0)



Model Simplifications and Uncertainties

- Uncertainty in parameters (a_0, b_0)
- Unmodeled (neglected) dynamics: electrical dynamics.
- Nonlinear effects: motor voltage "saturates" in *[0,3V]*
- Implementation effects: sampling, discrete-time updates, etc.





Control Design Objectives

The goal is to have the motor speed $y(t)$ follow a desired reference speed $r(t)$. The tracking error is $e(t) := r(t) - y(t)$.

Trade-offs are involved due to many competing objectives:

- Stability
- Reference tracking: rise and settling times, overshoot, steady-state error.
- Disturbance rejection
- Actuator effort
- Noise rejection
- Robustness to model uncertainty