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.

\[ u := \text{Voltage (V)} \]

\[ y := \text{rotational speed (rad/sec)} \]
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.

\[ u := \text{Voltage (V)} \]
\[ y := \text{rotational speed (rad/sec)} \]
Neglecting the “fast” electrical dynamics:

\[ \dot{y}(t) + a_0 y(t) = b_0 u(t) + b_0 d(t) \]

where: \( a_0 = 0.94 \frac{1}{\text{sec}} \) and \( b_0 = 766.8 \frac{\text{rad}}{\text{sec}^2 \text{V}} \)

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

\[ u := \text{Voltage (V)} \]

\[ y := \text{rotational speed (rad/sec)} \]
Nominal Step Responses

Transfer Function
\[ G(s) = \frac{766.8}{s + 0.94} \]

DC Gain
\[ G(0) = 815.7 \frac{\text{rad}}{\text{sec V}} \]

Settling Time
\[ 3\tau = 3.18 \text{sec} \]
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.
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