Mechanical Systems Laboratory
Integral Control; Introduction to Second Order Systems

1. Integral Control

Imagine that you use proportional feedback to control the velocity of a DC brushed motor:

where v= voltage input to current amplifier that powers the motor, ω = actual angular velocity of motor, sensed with a tachometer, ω_d = desired angular velocity, K = proportional feedback gain, alpha = proportionality constant relating v (i.e. current amplifier input) to torque output from motor, b = viscous friction.

Draw a block diagram to help you understand the physical parts to the system.

Problem: Show that there is a steady-state error in velocity due to the friction.

KEY IDEA: We can get rid of this steady-state error by using a proportional plus integral (PI) controller:

How does I control work? (try to explain it to your neighbor in words).

Integral control works in the following way:
If error e(t) does not equal zero, then $\int e(t)dt$ increases with time, and eventually the torque (which is proportional to this integral) becomes high enough to overcome friction.

The block diagram for a P-I compensator is:

What is the transfer function for this system?

This is an example of second order system, which behaves differently than a first order system.

	Typical behaviors in time domain (step response)	Typical behaviors in frequency domain
First order system	Stable Unstable	
Second order system		

Important Ideas: integral control can help remove steady state error. However, I-control adds dynamics to the system, which can lead to 2^{nd} order phenomena such as oscillation and resonance.