2/22/22 Lecture 14

ME 133

Last time:

- DC motors

Question: How does # pole effect motor performance?

In general:

less poles: less torque / more speed

more poles: more torque / less speed

→ "smooth" torque signal

other considerations: weight / efficiencies

Today:

(1) stepper motors

(2.) Analog signal Processing (intro)

Stepper Motors

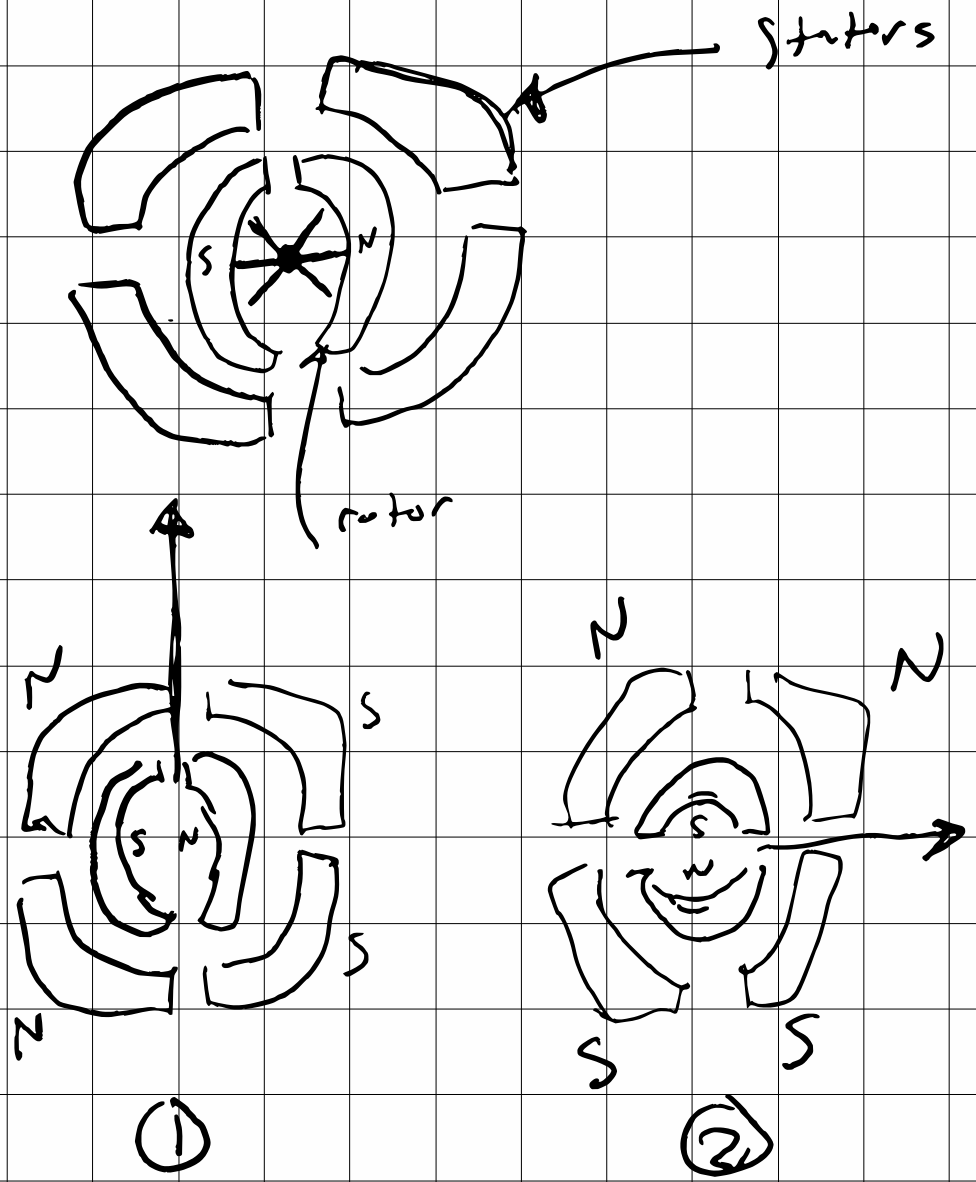
- permanent magnet DC motor
  - → rotate in both directions
  - → precise angular increments
  - → sustained holding torque
  - → easy to control digitally.

Steps: motor moves in accurate increments

steps per revolution		increments
12		30°
24		15°
72	→	5°
144		2.5°
180		2°
200		1.8°

micro stepping: 10K steps/rev.

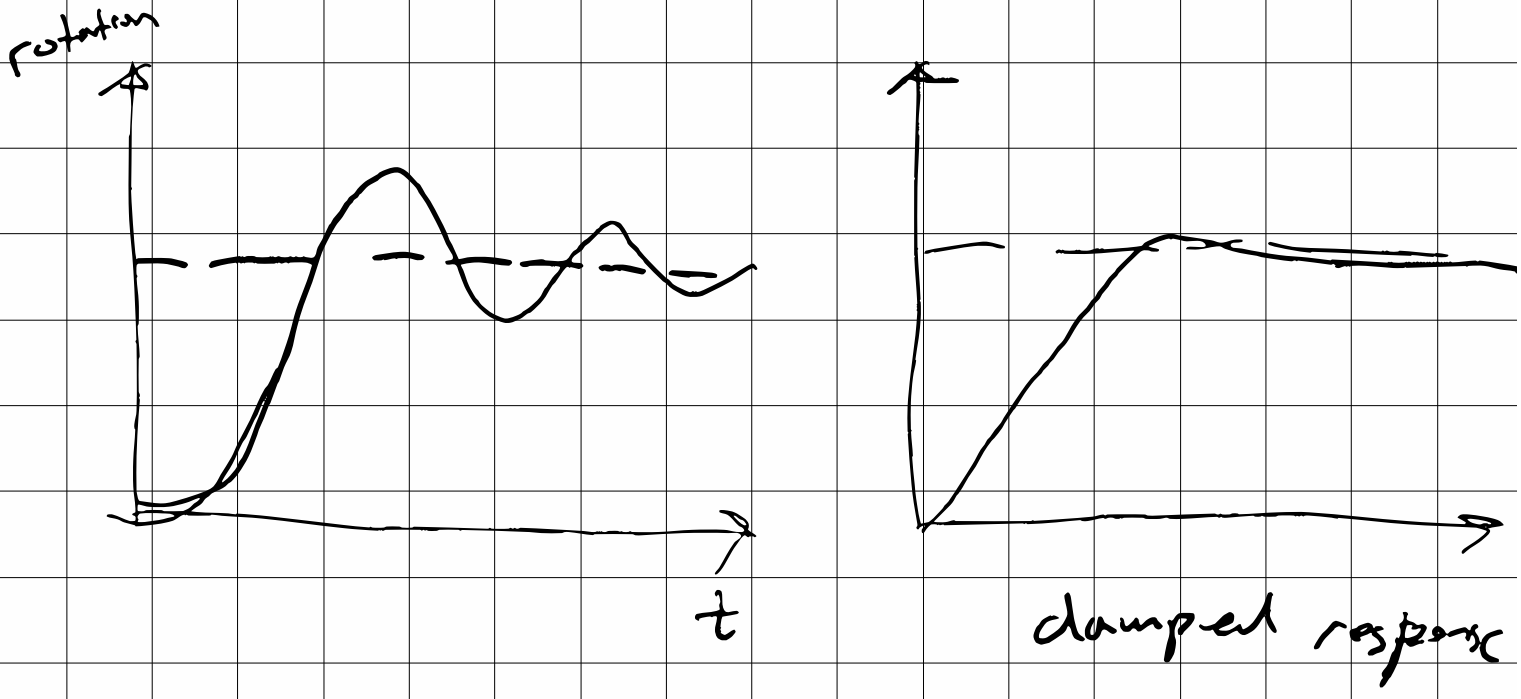
Basic Mechanical Principle

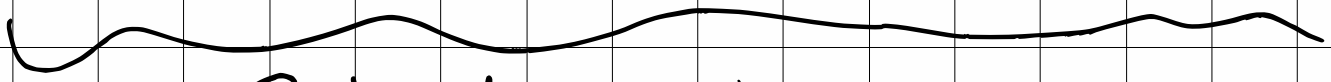


Dynamic Response

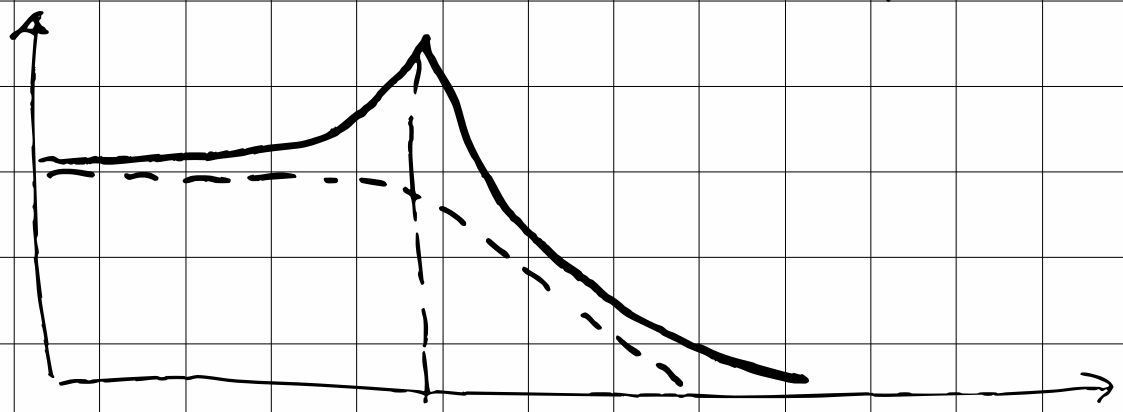
* high frequency application start/stop applications

* possibility for overshoot





2nd order system response

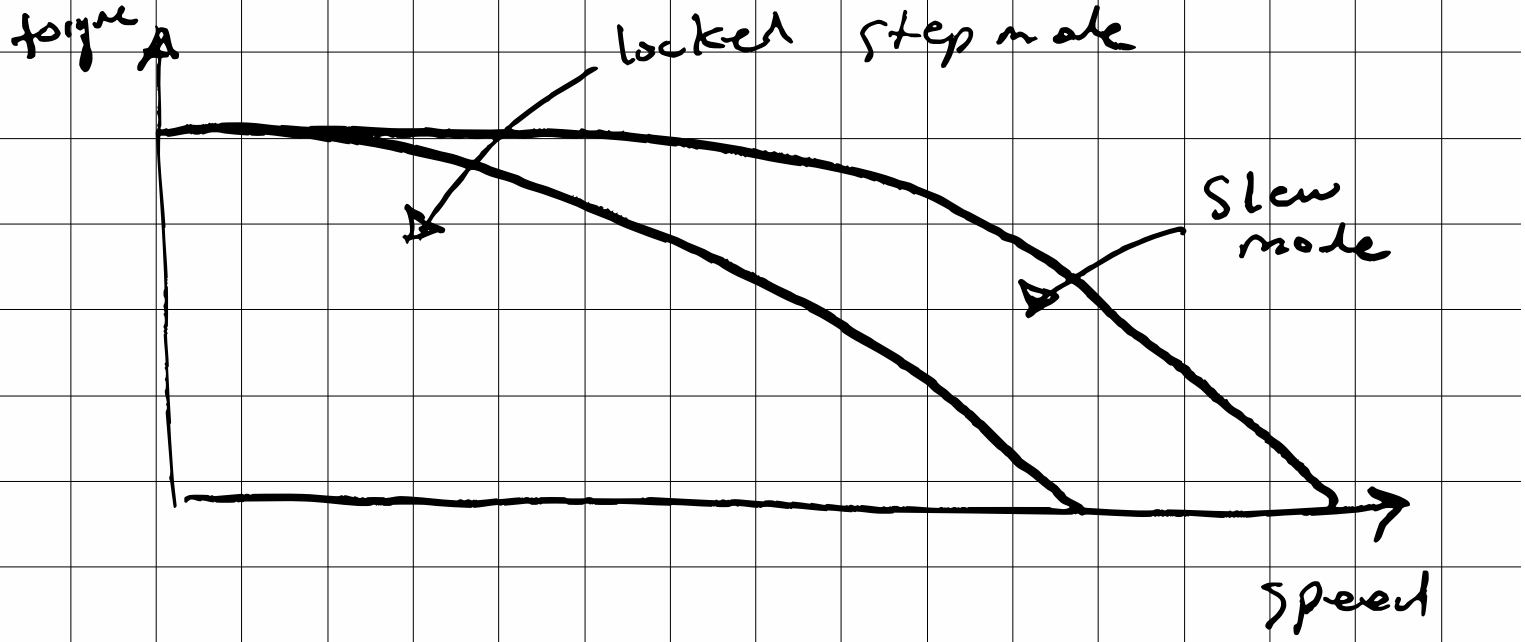


Torque - Speed characteristics

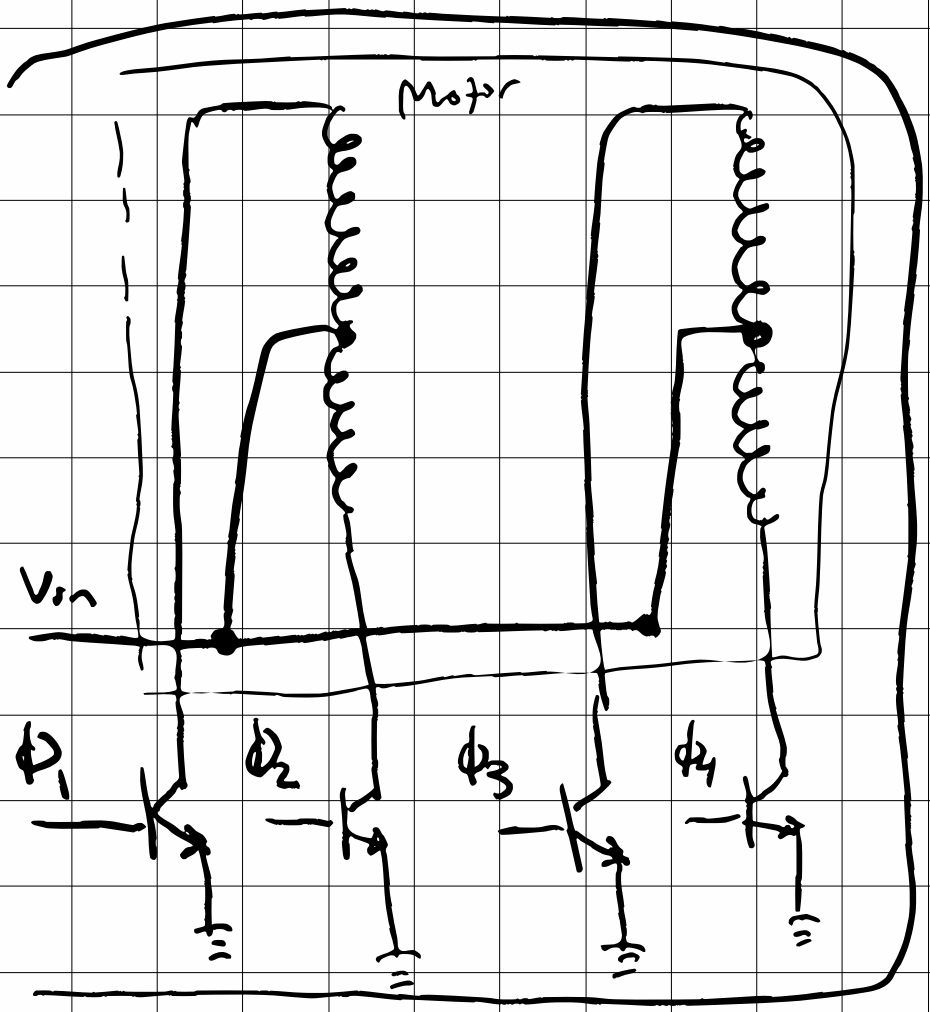
* two performance regions:

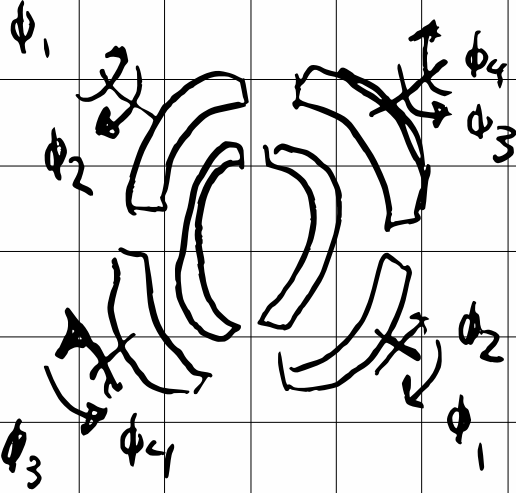
(1) locked step mode
→ motor decelerates (and can stop) between each step.

(2) Slewing mode
→ motor accelerates past steps must accelerate upto a slew speed.



Basic Unipolar control





Step	ϕ_1	ϕ_2	ϕ_3	ϕ_4
1	ON	OFF	ON	OFF
2	ON	Off	Off	ON
3	off	on	off	on
4	off	on	on	off

→ Bipolar H-bridge in the book.

Analog signal processing

Problem: often sensor outputs / actuator input are analog signal that need some form of conditioning (modifications)
→ signal processing

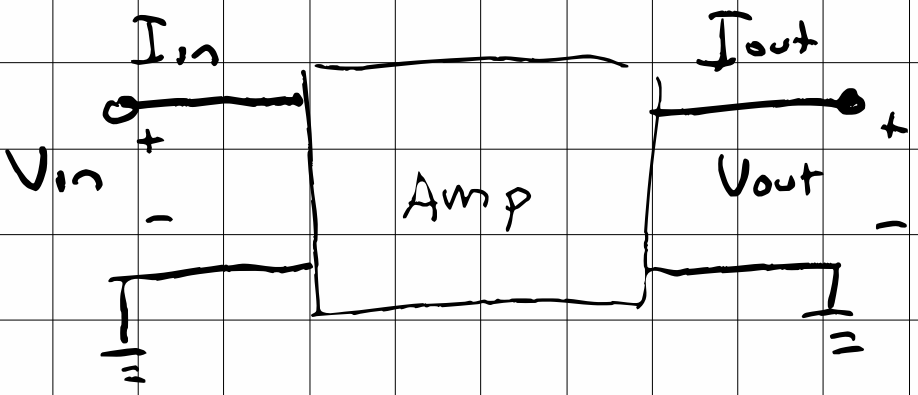
- too small
- noisy
- extra information
- DC offset

Forms of signal processing:

- amplification
- filtering
- differentiation
- integration
- addition
- etc.

Amplifiers

- Ideal amplifiers
  - linearity
  - large bandwidth
  - input/output impedance characteristics



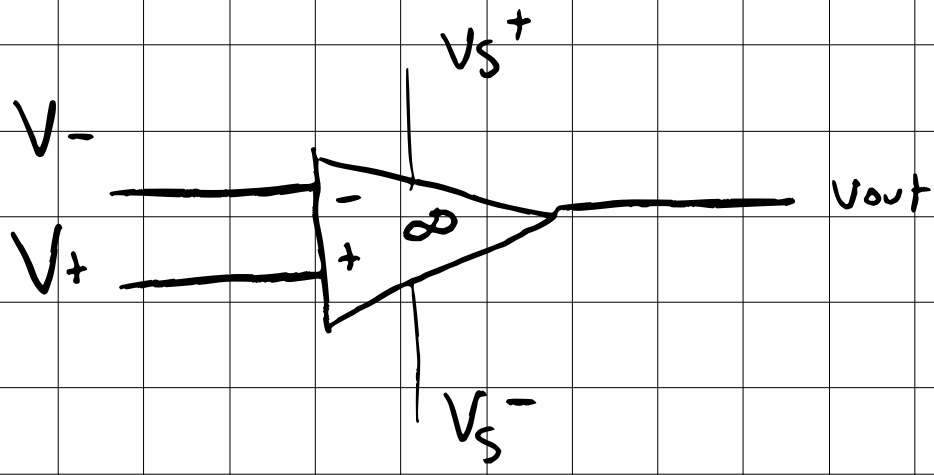
$$Z_{in} = \frac{V_{in}}{I_{in}} : \text{input impedance}$$

$$Z_{out} = \frac{V_{out}}{I_{out}} : \text{output impedance}$$

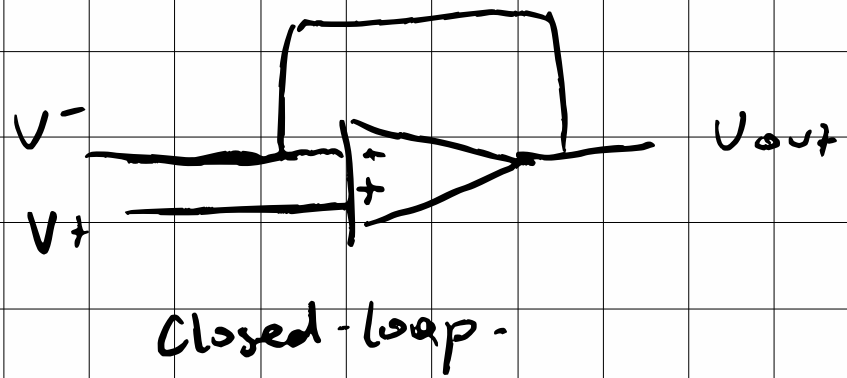
We want Z_{in} ↑ Z_{out} ↓

Operational Amplifier

* most important hardware component for analog signal processing

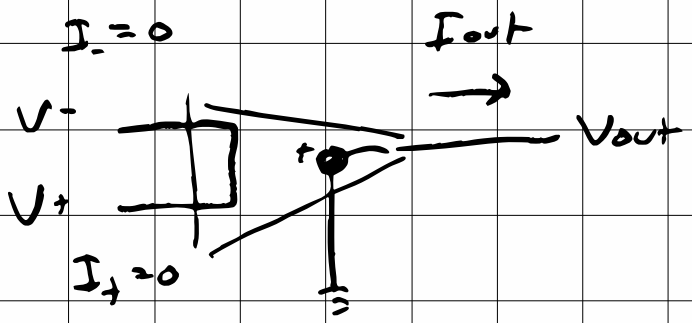


open loop → never used like this



Closed-loop.

Ideal op-amp Assumptions



(1) Infinite impedance at both inputs

$$I_- = I_+ = 0$$

(2.) Infinite gain:

$$V_+ = V_-$$

(3.) output impedance is zero:
Vout doesn't depend on Iout