EECS 373
Introduction To Embedded System Design

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Lecture 13: Power and Mechatronics

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Outline

- **Solenoids**
- Motors
  - DC
  - Stepper
  - Servo
  - Linear
- H bridges
- Shaft encoders

Solenoids

- Why?
  - Release kibble.
  - Ring bells.
  - Kick ball.
  - Open binary valve.
- Electromagnet-based actuator.
- Typically linear.
- Typically binary.
- Typically very fast.
- Poor controllability.
- Heat dissipation is major concern.
  - Only when on.
- Major E and EM noise source!

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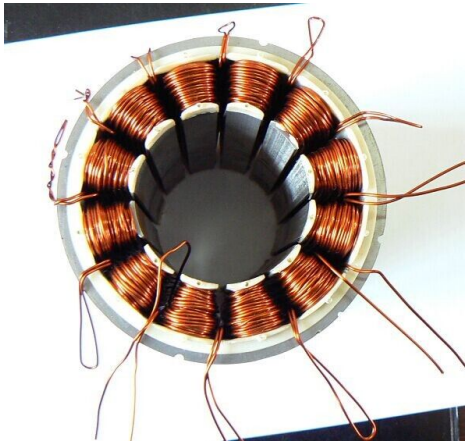
DC motors

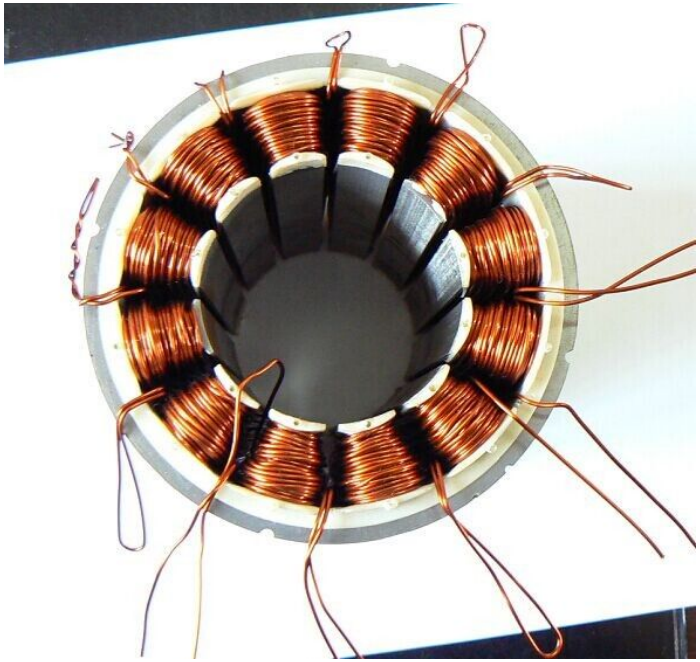
- General purpose: turn things.
- Must switch magnetic field polarity during turn.
  - Brushed: carbon common, wears out.
  - Brushless: solid-state DC → AC converter first.
- Back-EMF
  - Motors are also generators.
    - When turning, opposes applied voltage.
  - Speed-dependent: bigger when moving.
  - Noise source.
  - Permits current regulation.

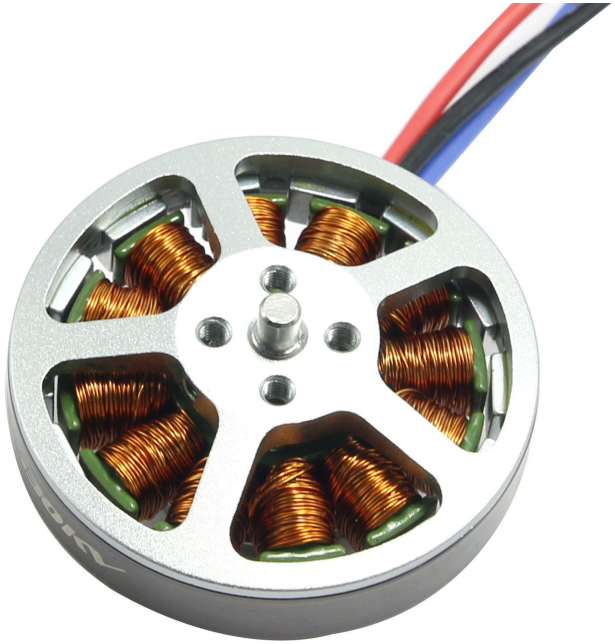


Drone/disc motors

Big advanced for UAVs/drones.

- Wide instead of long. Better heat dissipation.
- High-efficiency.
- High-torque.
- Require special drivers.
- Require sensors.





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Stepper motors

- Position at precise orientation.
- Toothed magnets.
  - Moves in small increments.
- High torque when stationary.
- Torque drops a lot at high speed.
- Works w.o. sensors / back EMF based control.
  - Don't use open-loop anywhere near limits.
- Reliable.
- Lock-in requires continued power.
- Use for precise orientation control.

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Servo motors

- Position at very precise (continuous) orientation.
- Requires sensors for closed-loop control system.
- Zero power once at rest.
- Expensive.

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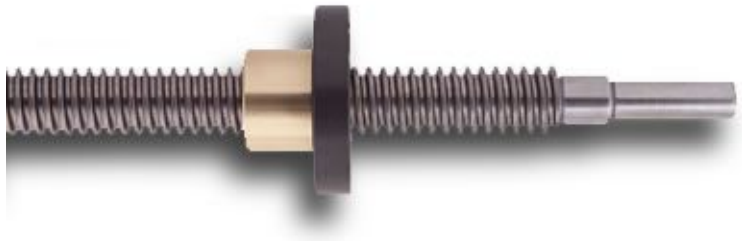
Linear motors/actuators

- Increasing force, but with reduced speed.
- Moving objects along long paths.
- Unwind stator → linear array of electromagnets can be used.
- Leadscrews and rotary motors are more common.



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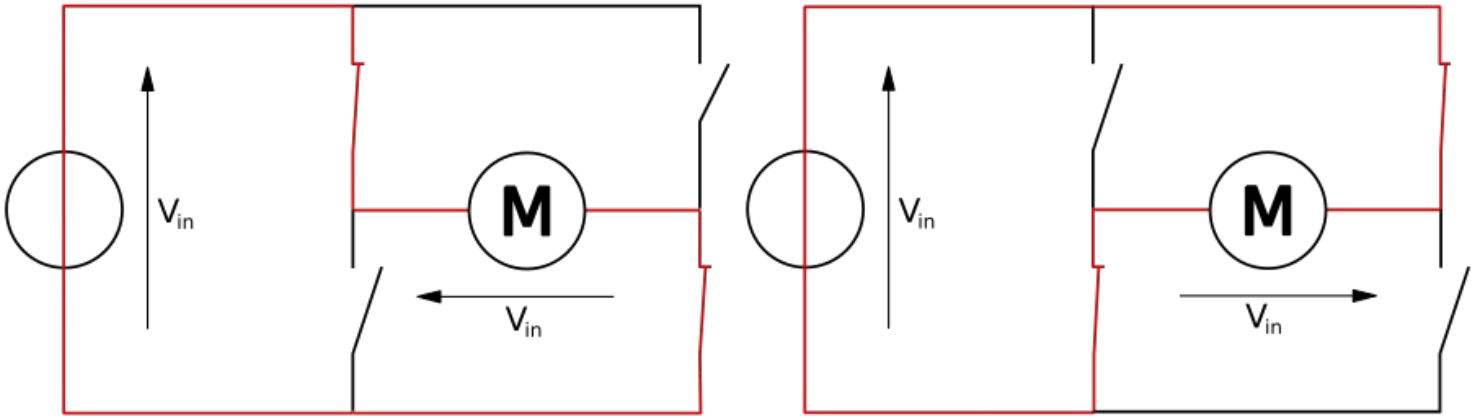
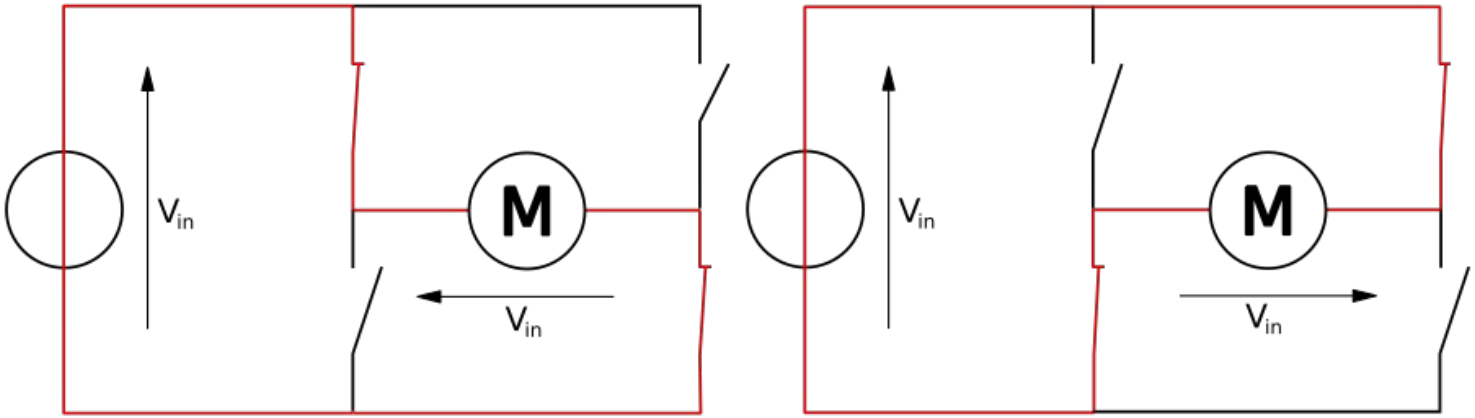
H bridges

- Why? Control direction of current through device.
- How? BJTs or FETs on “H” legs.



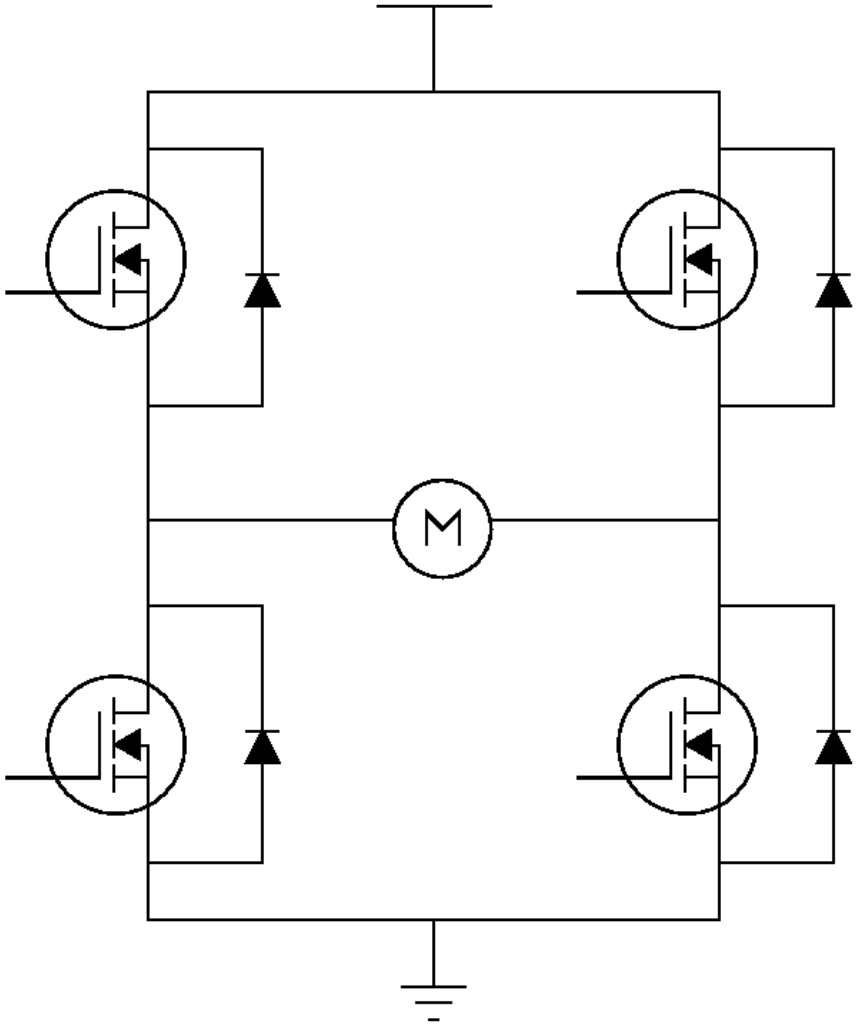
H bridge diodes

- What can go wrong?
  - Switch suddenly.
  - Inductors buck change in current.
  - Stored energy in coil produces large reverse voltage until discharged.
  - If FETs are off (they are), can be destroyed.



H bridge diodes

- Use diode in || with each switch.
- May be free w. MOSFETs.
- Where does current go when FET off?



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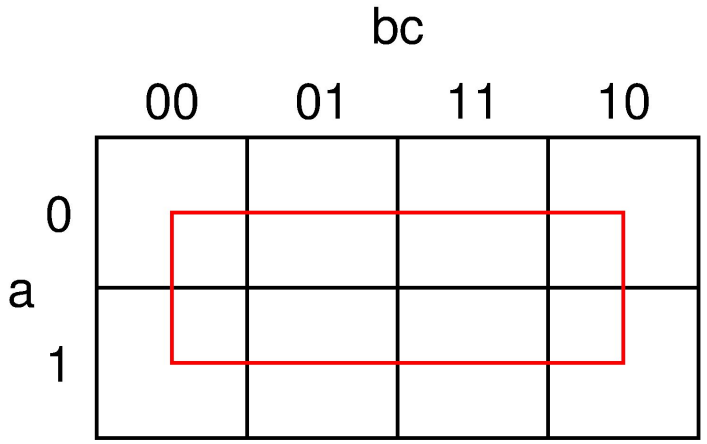
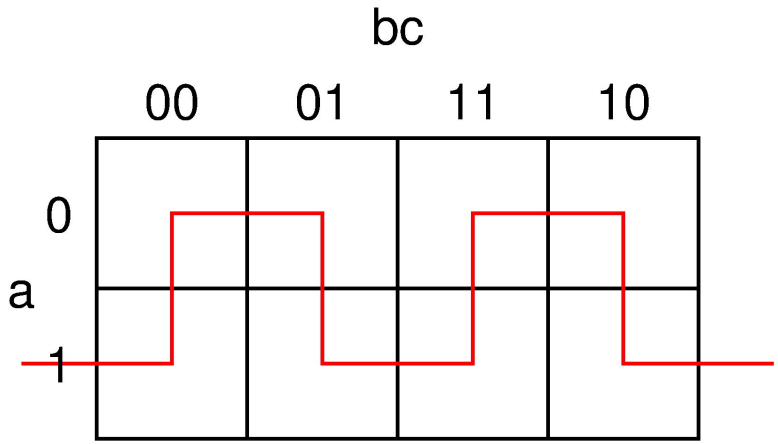
Shaft encoders

- Why? Know relative or absolute orientation.
- Linear arrangement of binary numbers.
- Can reuse numbers.
  - Lose absolute position.
- Adjacency essential.
  - Race conditions.

Shaft encoders

- How to design?
  - Adjacency map cycle.
  - 000 → 001 → 011 →
  - 010 → 110 → 111 →
  - 101 → 100 →
  - 0 → 1 → 0 → 1 fine, too.
- How to read?
  - LED+photodetector.
  - Reflective or transmissive.





Summary: you don't know motors

- You do know enough to get started.
- Have some understanding of uses.
- Strengths and weaknesses.

Done.