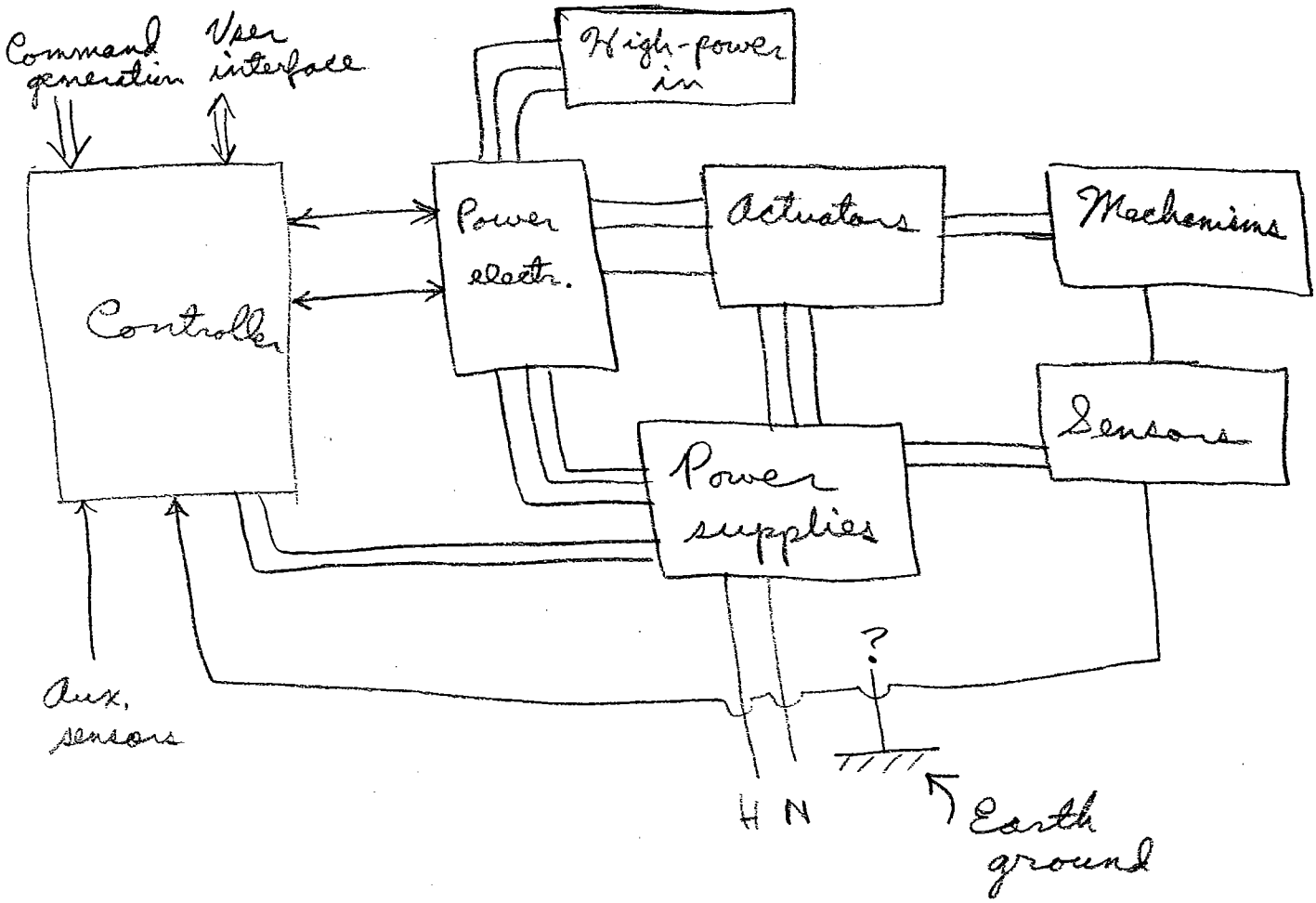
System interconnection issues:



- How to manage electrical connections?
- What to ground? Where?
- How to solve electrical noise problems?
- How to accurately transduce sensor signals and actuator commands?

- Connections between subsystems:

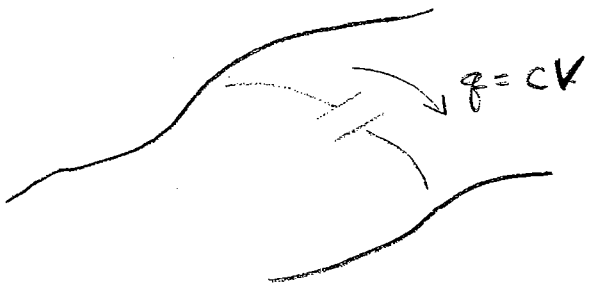
  Two principal approaches:

  a) Tie commons and chassis grounds together extensively; try to keep systems at equal potentials

  b) keep subsystems electrically separate; use differential or instrumentation amplifiers for analog connections, opto-isolators for digital connections

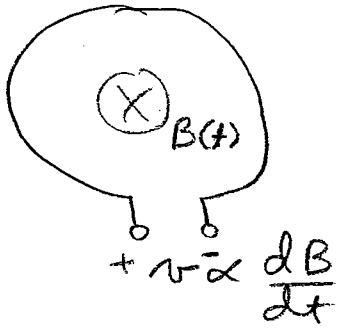
- Key is to think about where currents will flow and how disturbances are coupled

E



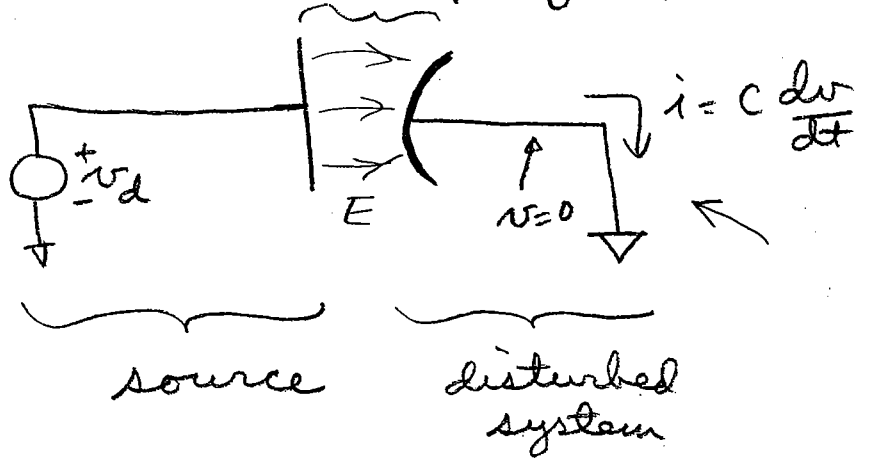
Electric field coupling via stray capacitance

B

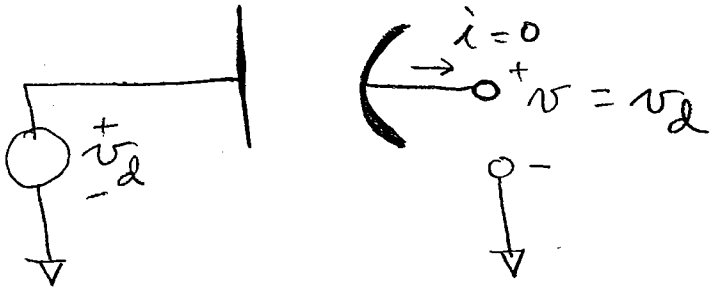


Magnetic field coupling via stray mutual inductance

E-coupling:

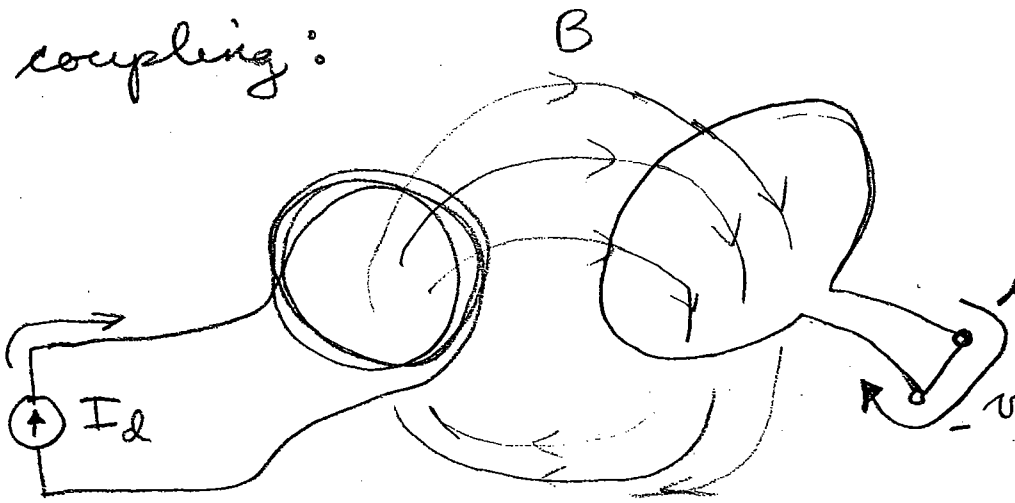


If disturbed system has a <u>low impedance</u> to ground, a current is injected



If disturbed system has a <u>high impedance</u>, no current is injected but the voltage is driven away from ground

B - coupling:



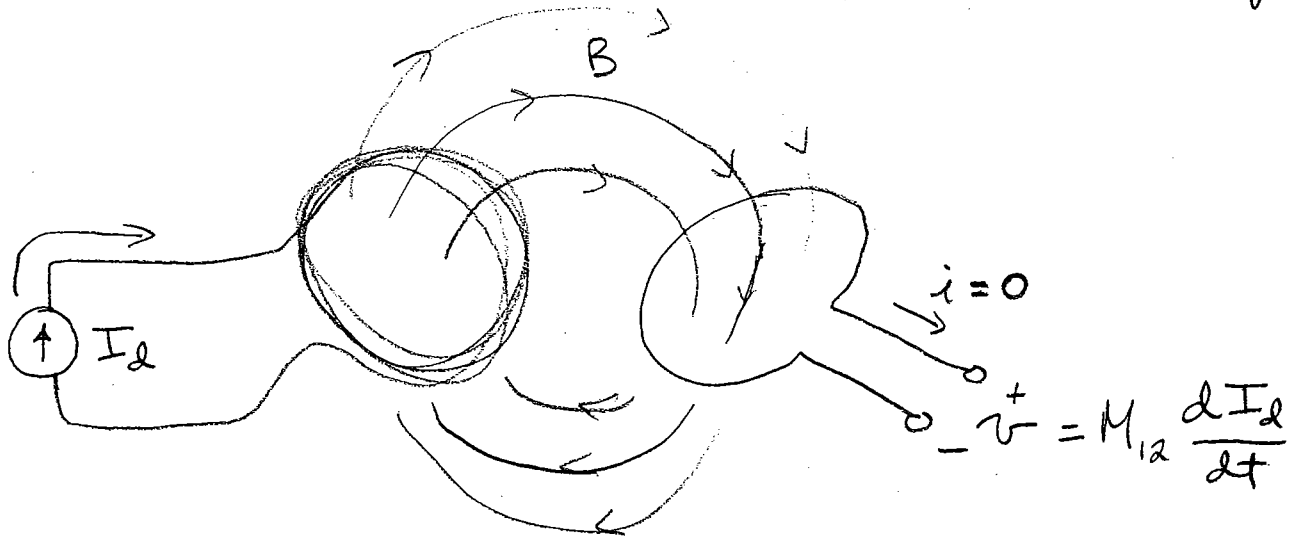
mutual inductance

$$i = M_{12} I_d$$

source

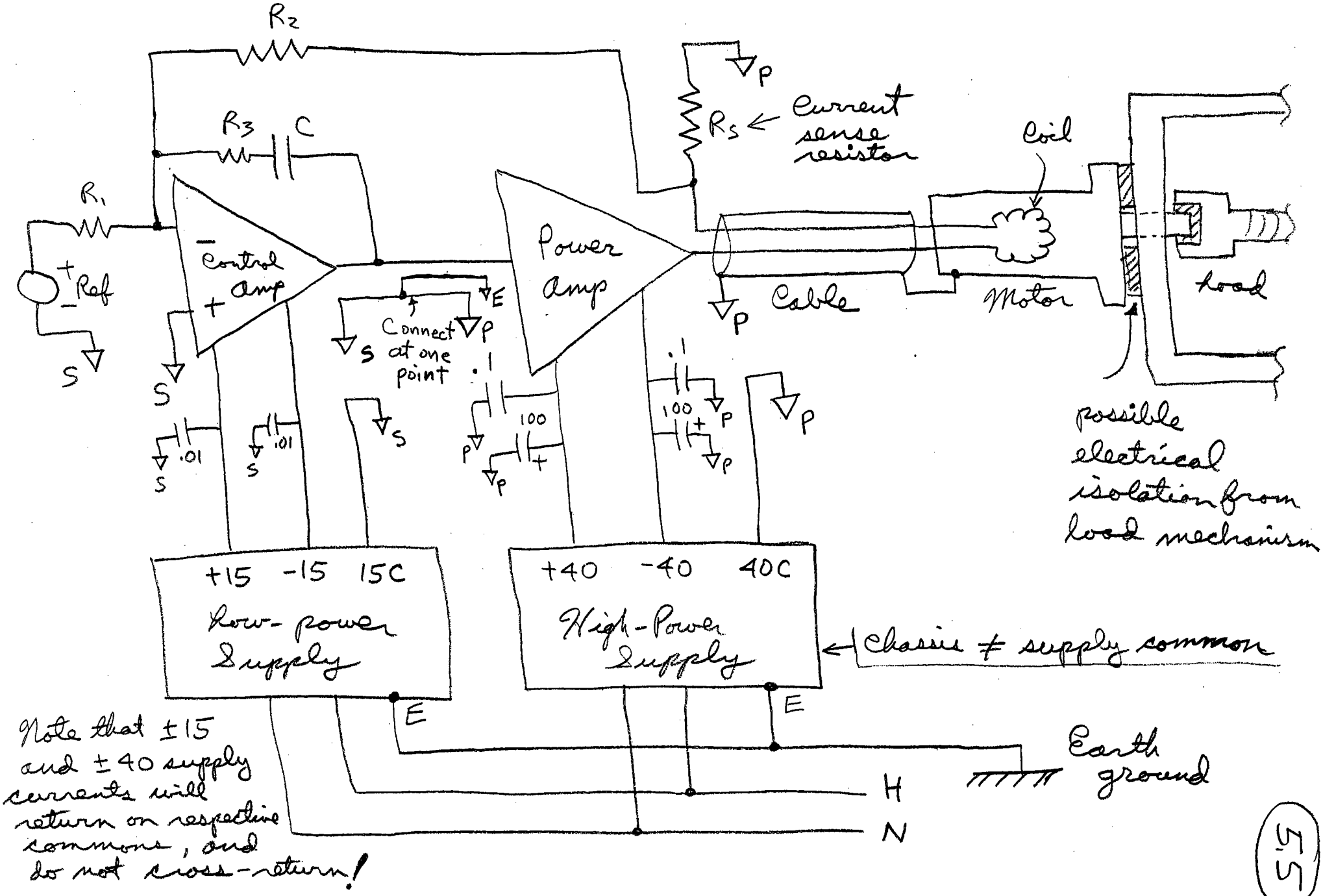
disturbed system

If disturbed system has a low impedance, a disturbance current will flow



If disturbed system has a high-impedance, a disturbance voltage will be generated

System layout: Current control loop for motor drive



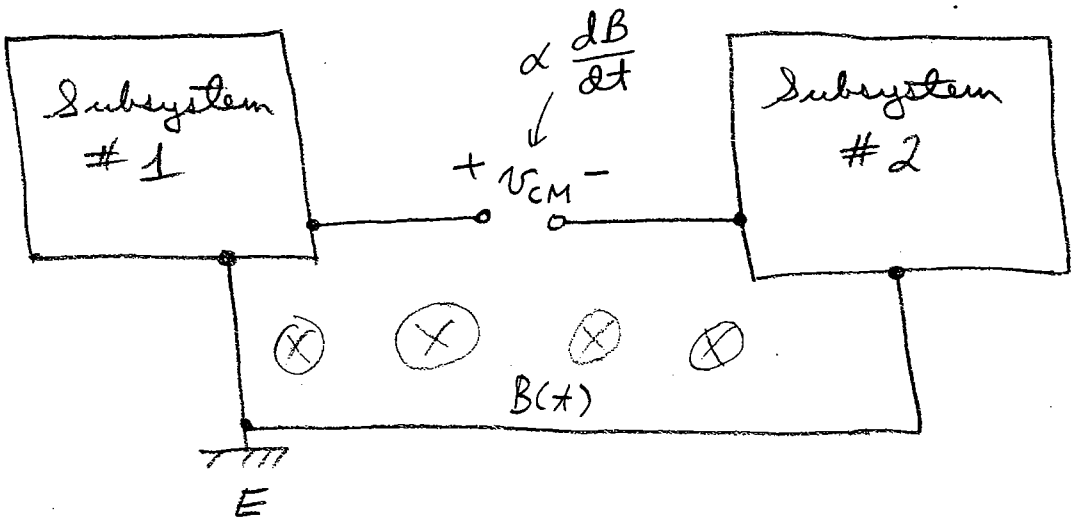
- Target board must have a good ground plane. (5.5.1)
- In any of these arrangements be sure to maintain connection to earth ground for safety reasons

- We assume that the supply common can be "floated" with respect to chassis ground and the power hot (H) and neutral (N). This is not always the case; may need to use an isolation transformer.

- Key advantage here is that supply commons only meet at one point on the target board. This is also the point where the board common is tied to ground. The commons <u>are not</u> connected back at the supplies. Result: Each supply current returns only on its associated common, and <u>not</u> on other commons or the ground wire.
- Pet peeve: open-frame supplies

- Connections between subsystems

- Due to magnetic and electric field coupling, separate subsystems exhibit a common-mode voltage difference

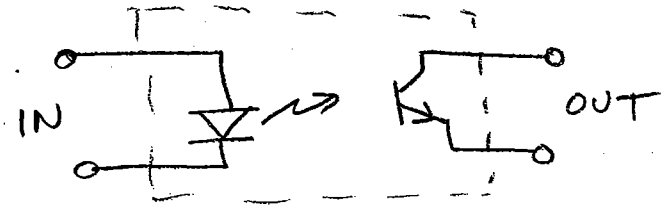


- If you try to connect the commons a ground loop current will flow, and will generate error voltages

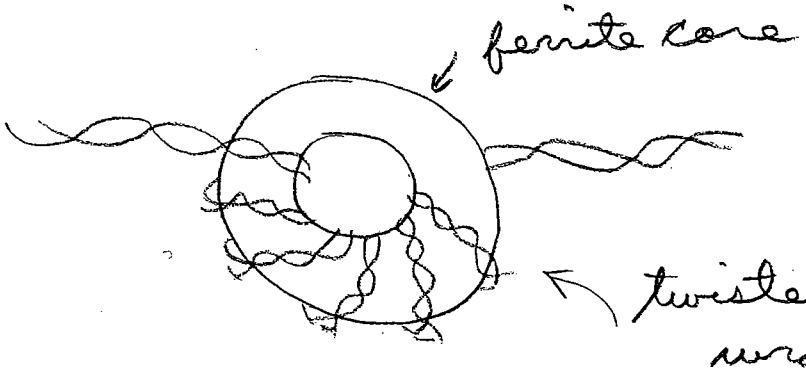
- If you don't connect the commons, you have to manage the common mode voltage v_{CM}.

- Ways to absorb common-mode voltage, i.e. allow it to be there but not allow it to disturb the communication of signals

- Opto-isolator

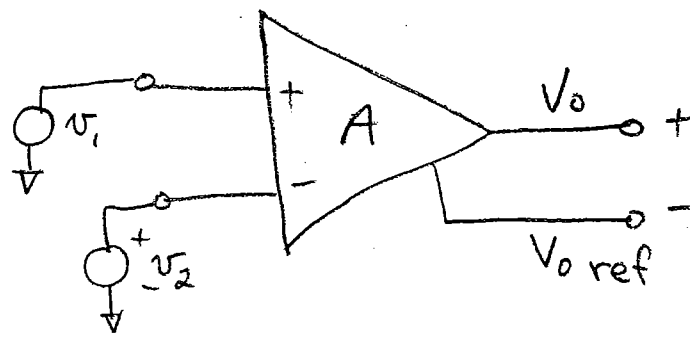


- Common-mode choke



- Differential amplifier:

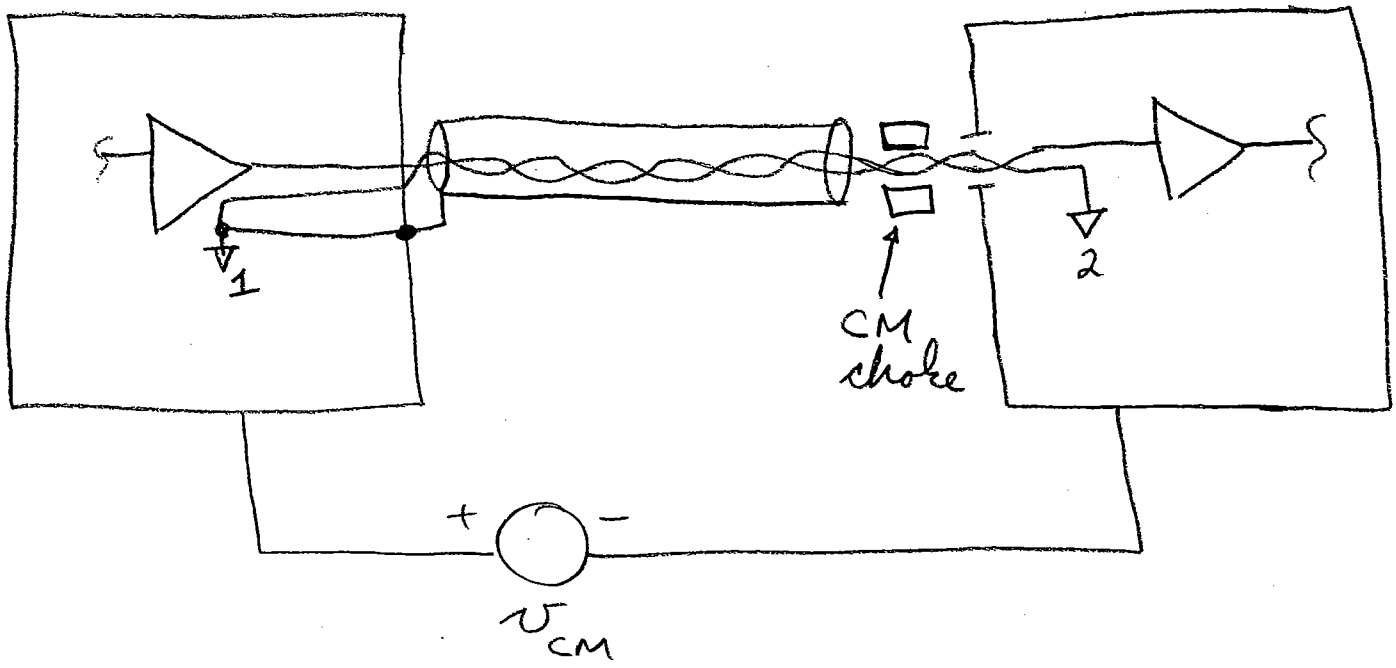
$$v_{CM} \triangleq \frac{v_1 + v_2}{2}$$



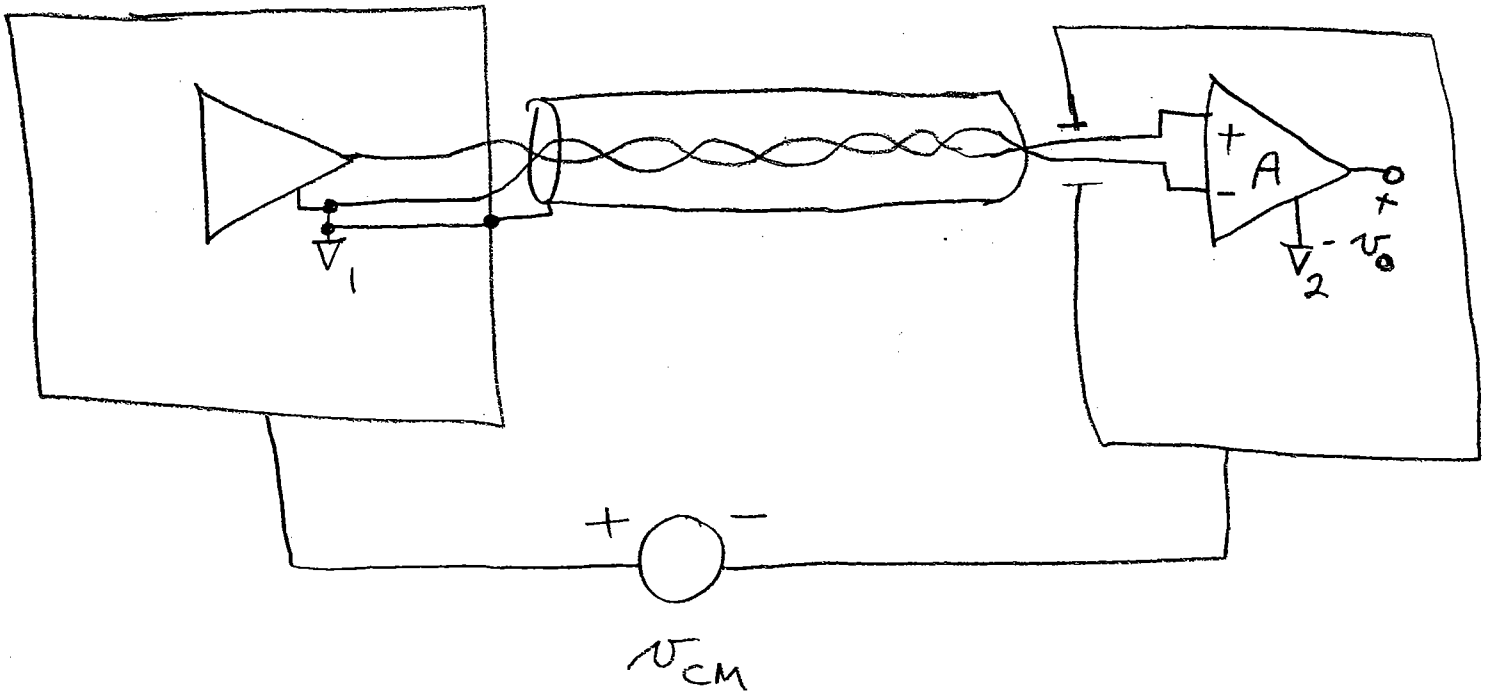
$$v = A(v_1 - v_2)$$

BUT, to eliminate E-field pickup, we need to shield to connections. Shield cannot be connected on both ends.

- w/ choke



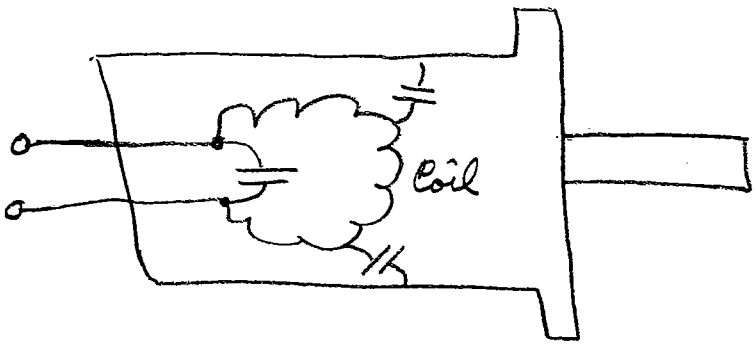
- w/ differential amplifier



Shield generally connected back to source, not connected to receiver

- Switching amplifiers are particularly nasty, but can be tamed if you think carefully about how commons are tied, managing E-field-coupled noise and B-field-coupled noise.

- Motor feedthrough and stray capacitances are particularly problematic



- Load seen by switching amp needs to be inductive to prevent high-amplitude current spikes at each switching instant.

Switching amplifier connections