

Lecture 7: Instrumentation Amplifier

(Quiz)

0. Review

1. Inst Amp Basics

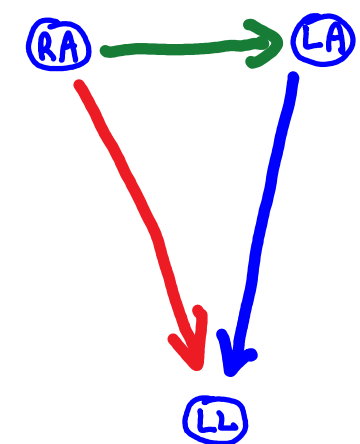
2. Common Mode Rejection Ratio
(CMRR)

- PreLab 3 due at lab session
- Thu (Jan 30): HW3
- Fri (Jan 31): Lab 2 report
- Exam #1 (Feb 6)!
 - HW 1, 2, 3 material
 - Lectures 1-8
 - Course website will have sample exam + solutions

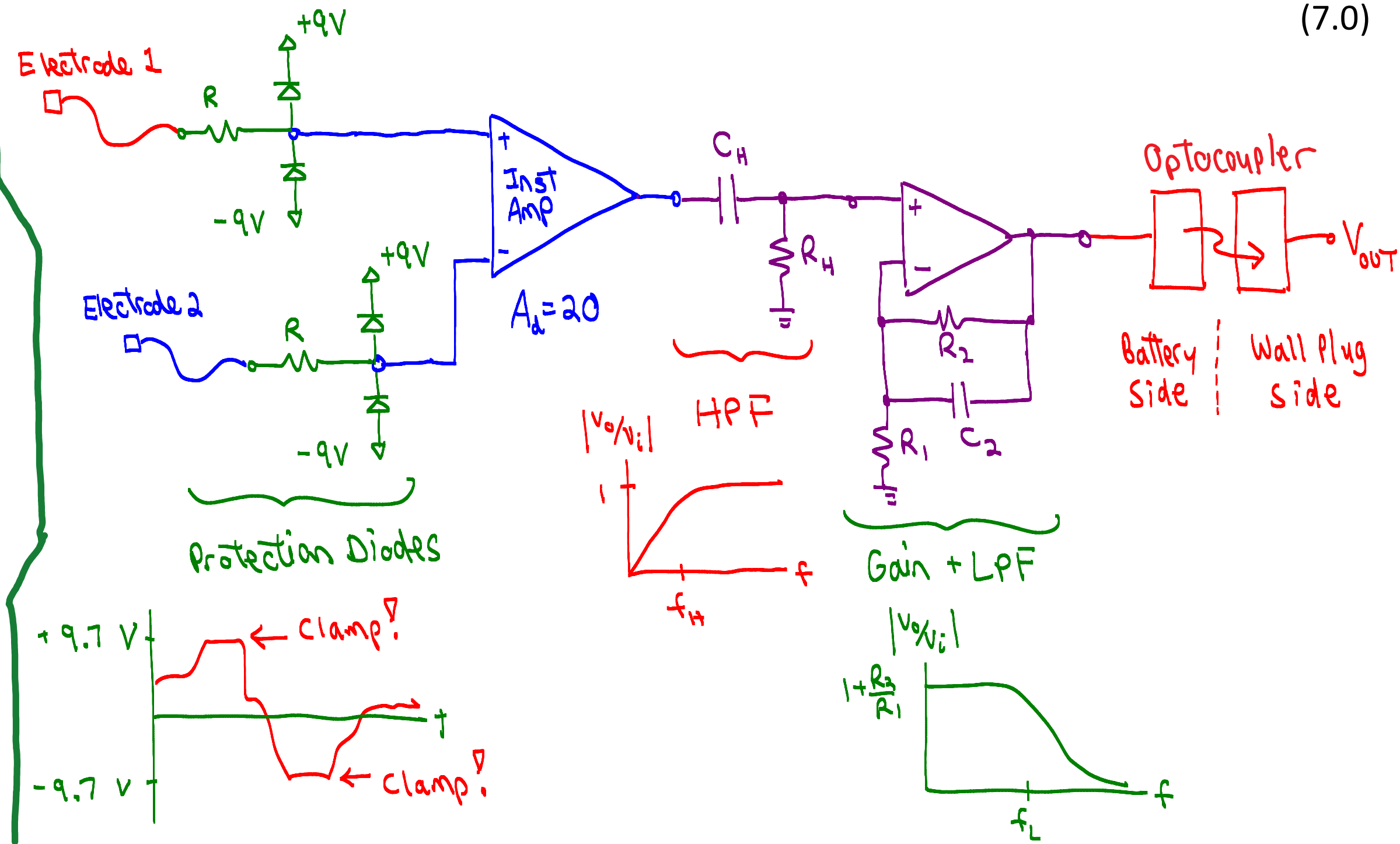
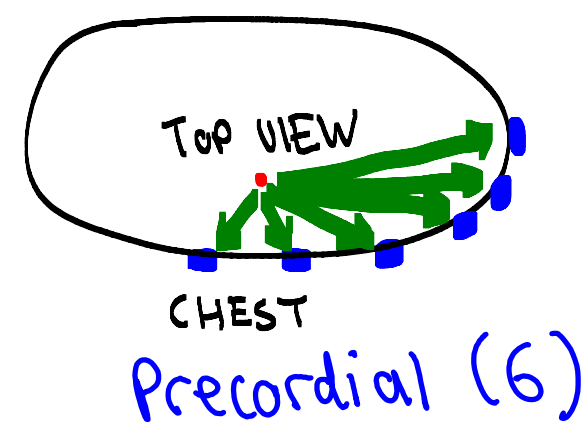
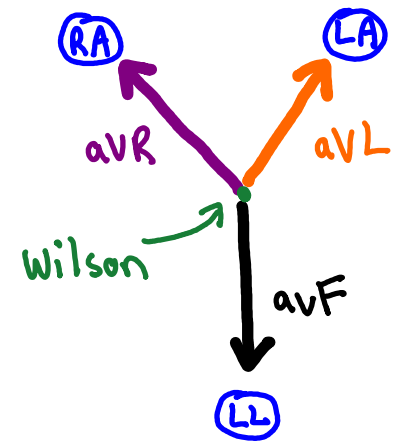
0. Review

12-Lead ECG

(3) Einthoven's Triangle

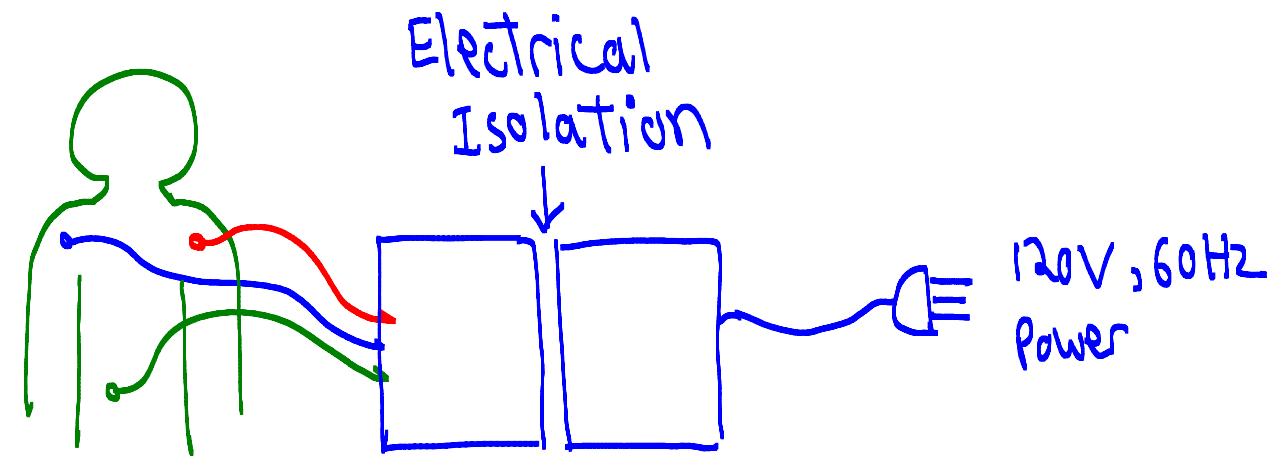


(3) Augmented

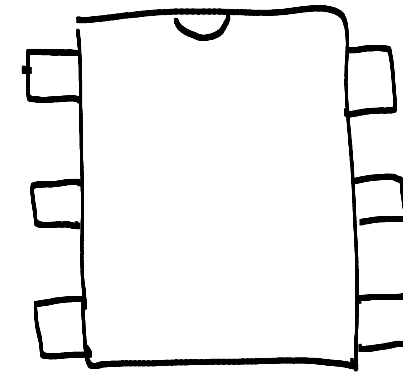
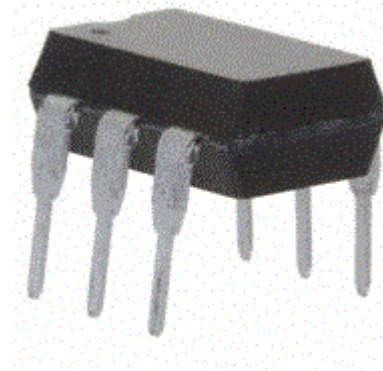


★ Isolation

- ECG systems must minimize the possibility of the patient coming in contact with 120V power line



★ An optocoupler (or photocoupler) is a common way to achieve



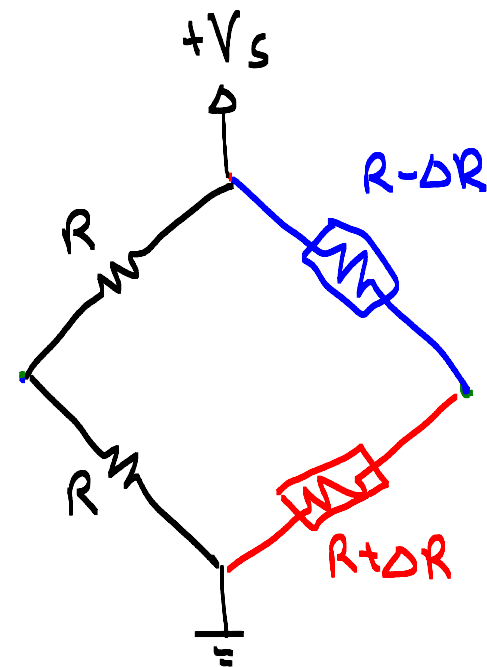
1. Instrumentation Amplifier Basics

A. Differential Amplifier

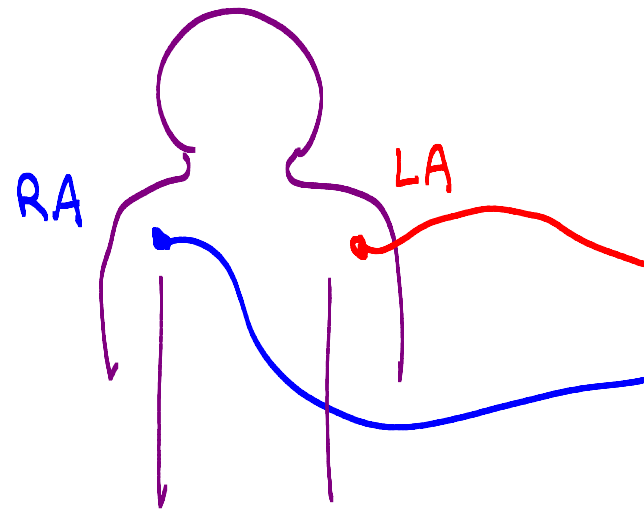
- Many sensors produce a differential output voltage

Ex:

Strain
Gage



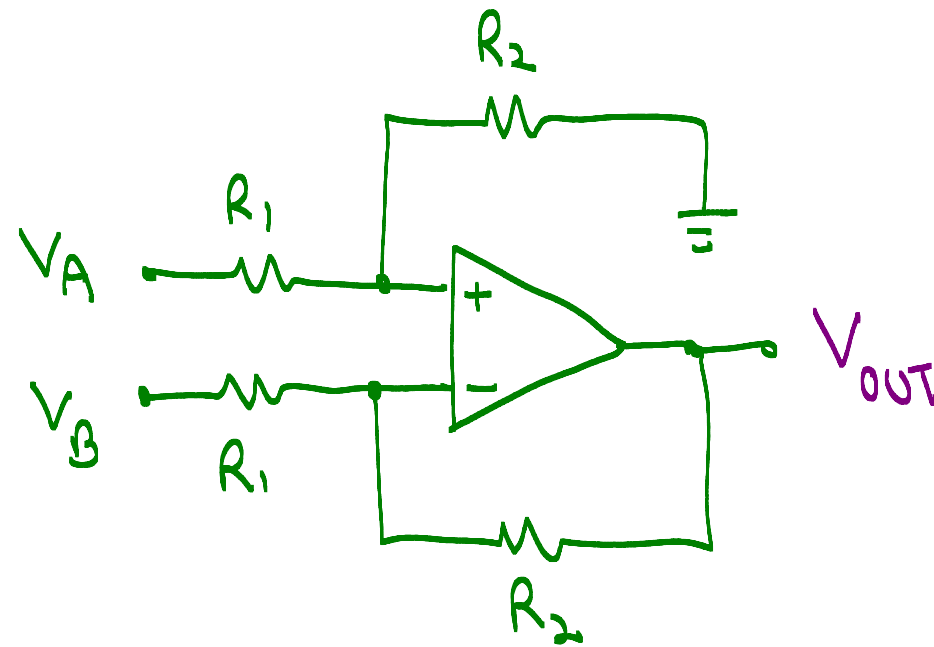
- In ECG, we want to amplify the voltage between 2 electrodes



B. Single op-Amp Differential Amplifier

Simplest type of diff amp:

KCL at node V_- :



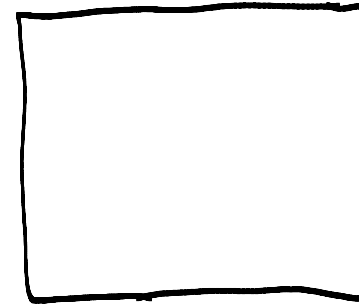
- Major drawback of single op amp diff amplifier is _____

Who cares?

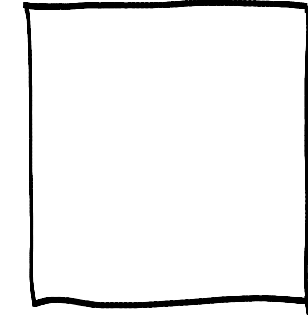
① Sensor can be viewed as a

② Amplifier looks like a

Sensor



Amplifier

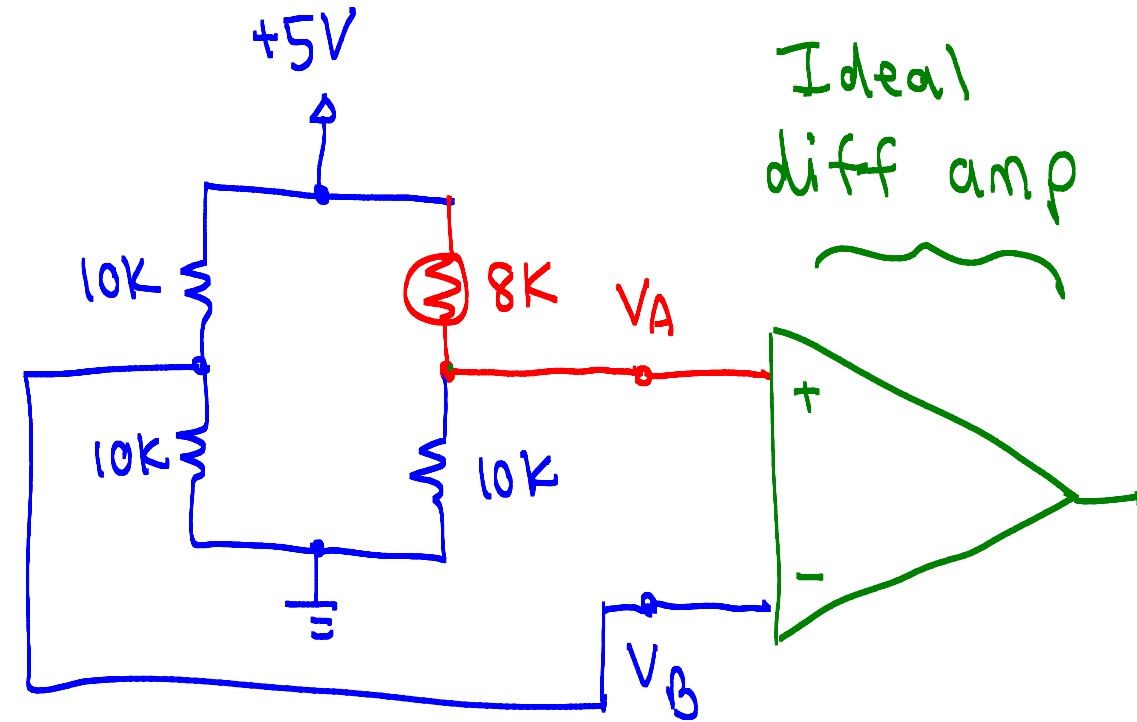


Example Thermistor Circuit

- By itself, the bridge produces

$$V_A =$$

$$V_B =$$



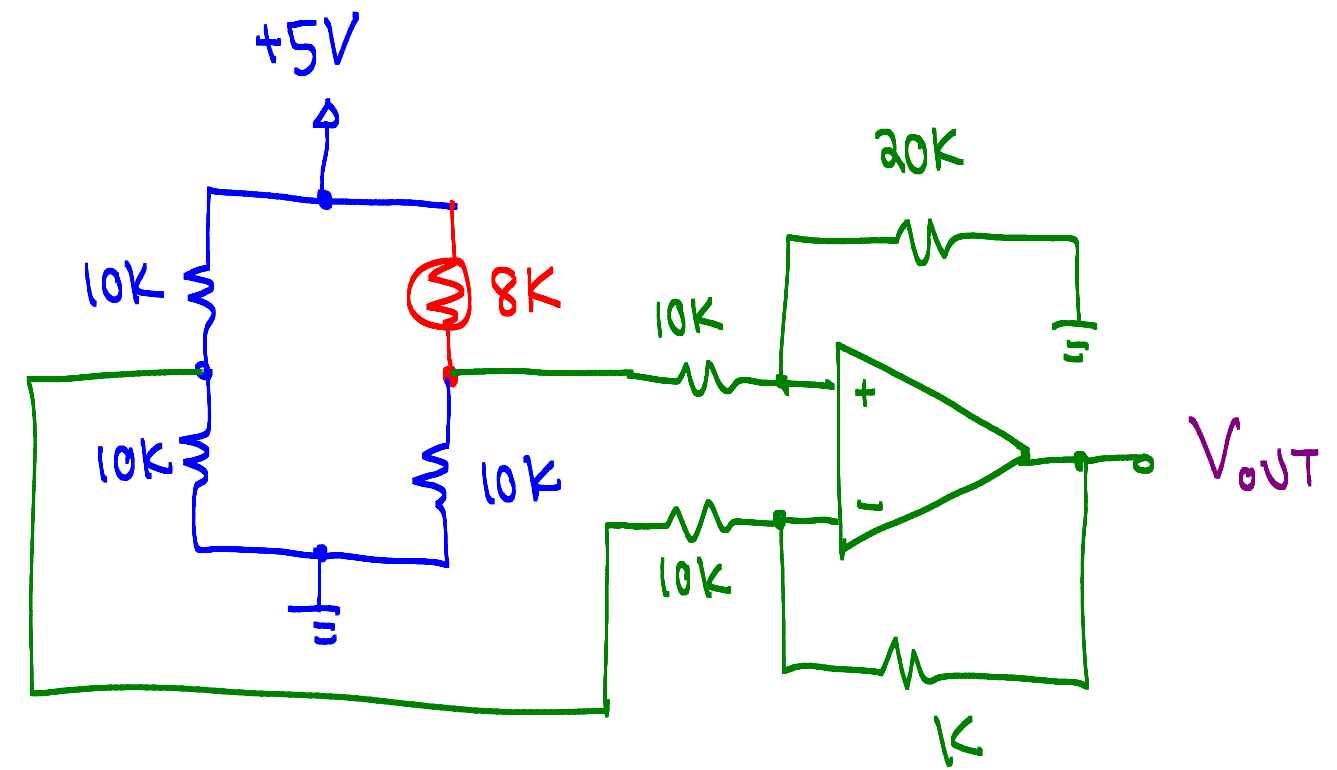
- Ideally, a diff amplifier ($A_d=2$) produces:

- Now consider using a single op amp diff amplifier.

Derivation:

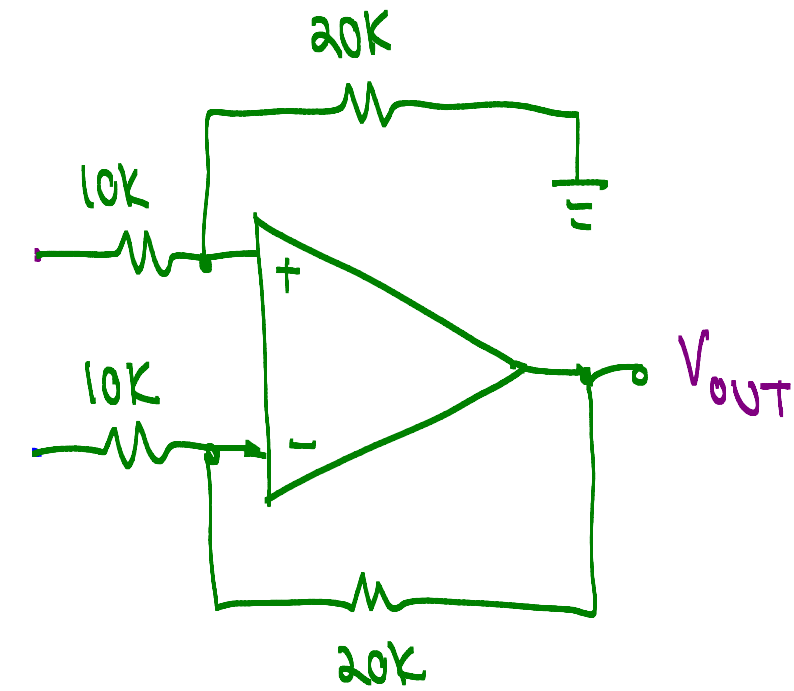
①

(7.5)



② Use Golden Rules
on new circuit:

KCL at node V_- :



- An instrumentation amplifier is a very high quality diff amplifier

①

APPLICATIONS

Weigh scales

ECG and medical instrumentation

Transducer interface

Data acquisition systems

Industrial process controls

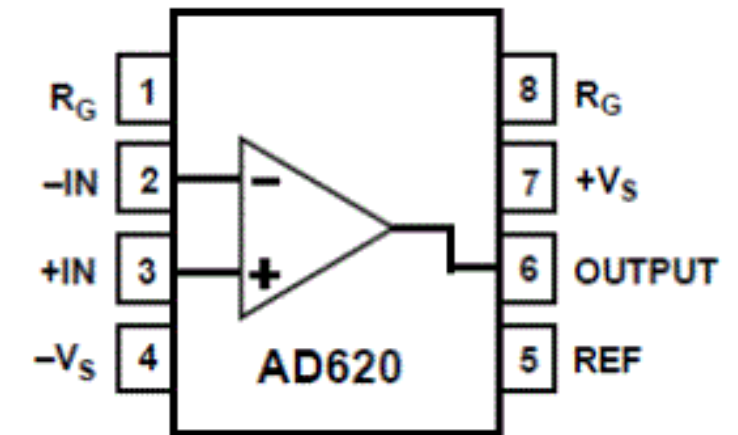
Battery-powered and portable equipment

②



Low Cost Low Power
Instrumentation Amplifier

AD620



2. Common Mode Rejection Ratio (CMRR)

- Ideal output of inst amp:

$$V_{OUT} =$$

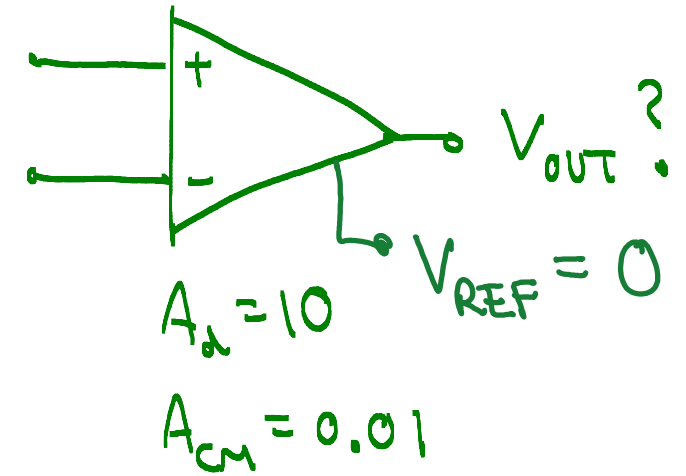
- In reality, an extra "error" term exists!

$$V_{OUT} =$$

Example

$$2.55V$$

$$2.45V$$



7.8

①

②

- Common Mode Rejection Ratio

Example:

ECG input is PQRS T waveform with 0.5 mV peak R-wave. Power line interference causes common mode voltage with 1 V_{pp} amplitude.

①

②

If $A_d = 30$ and $CMRR = 80$ dB,
what is V_{out} ?

③ output: $V_{out} =$