HW #2

① 12 bit A/D converter 12 bits, $0 \le V_{in} < 5.0\,V$

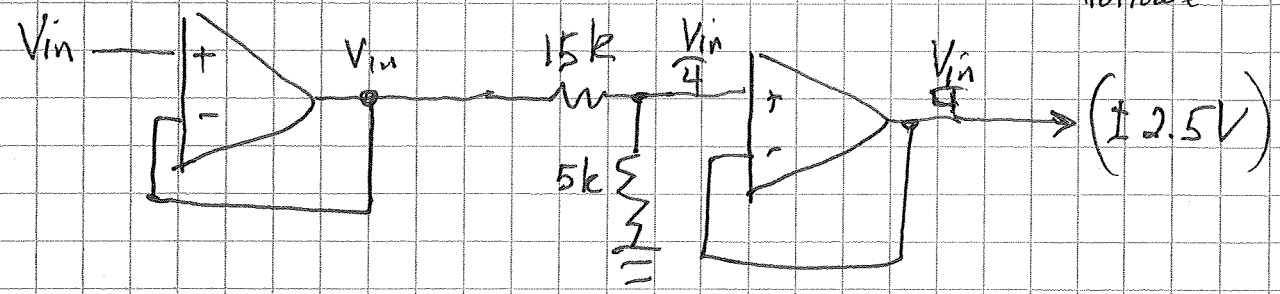
(a) Design circuit to allow V_{in} from $-10V$ to $+10V$ to be converted.

(i) compress range to $\pm 2.5V$ $\Rightarrow \div 4$

(ii) shift to 0 to $+5\,V$

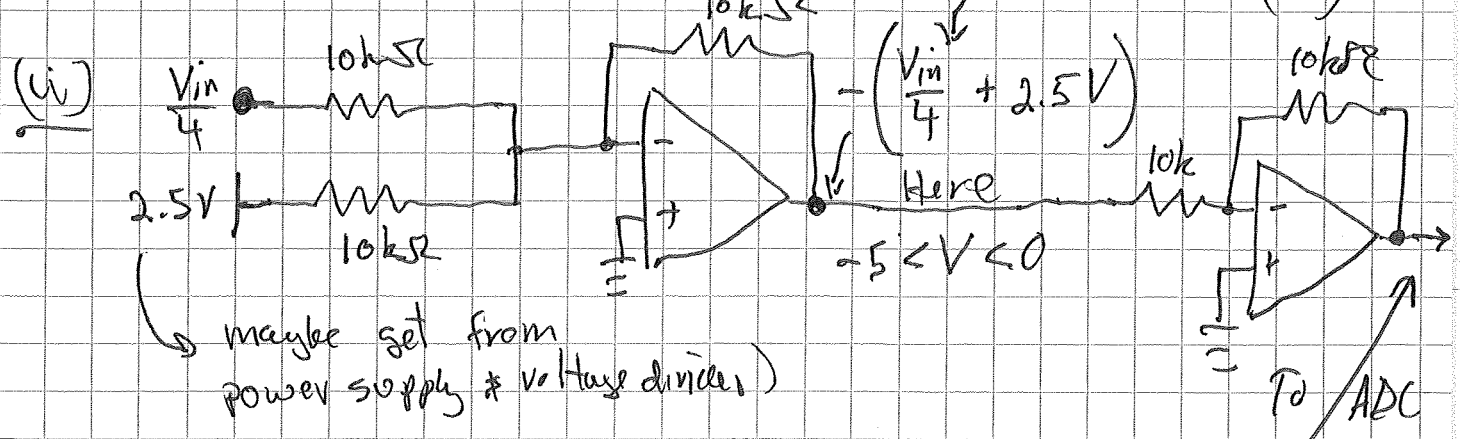
To draw little current start with a voltage follower with $\div 4$ divider after op-amp, then another follower

(i)



Then shift with voltage adder and invert → x(-1)

(ii)



(maybe get from power supply * voltage divider)

(b) 12 bits $\Rightarrow$ $0 \le B < 2^{12} - 1$

or 4096 values

so original input voltage $\pm 10V$ has a 20V range divided in 2^{12} steps

$$0 \le V_{ADC} \le 5.0V$$

$$\Delta V_{in} = \frac{20V}{2^{12}} = 4.88\,mV$$

so $\sim 5\,mV$ changes B output of ADC by 1 count (binary)

(2) Piezo scanner $\Delta X = \alpha \Delta V$

$\alpha = 8.0 \frac{nm}{V}$ nm = nanometer = 10^{-9} m

12 bit DAC and ±100V range ⇒ smallest

$\Delta V = \frac{200V}{2^{12}} = .0488\ V$

(a) And with total swing from −100V to +100V

biggest (total) $\Delta X = \frac{8nm}{V} \cdot 200V = 1600\ nm = 1.6\ \mu m$ total travel

(b) Smallest step is $\Delta X_{min} = \frac{200V}{2^{12}} \cdot \frac{8\ nm}{V}$

$= (48.8\ mV)\left(8.0 \frac{nm}{V}\right)$

$\Delta X_{min} = 0.39\ nm\ (= 3.9\ \text{Å})$

This is comparable to interatomic distances in a solid (a few × 0.1 nm)

(c) 16 bit DAC ⇒ smallest $\Delta V = \frac{200V}{2^{16}} = 3.05\ mV$

(4 more bits ⇒ 16× smaller steps)

$\Delta X_{min} = \left(8.0 \frac{nm}{V}\right) \cdot (3.05\ mV)$

$= .0244\ nm = 24.4\ pm$ (10^{-12})

(½ the Bohr radius of Hydrogen atom)