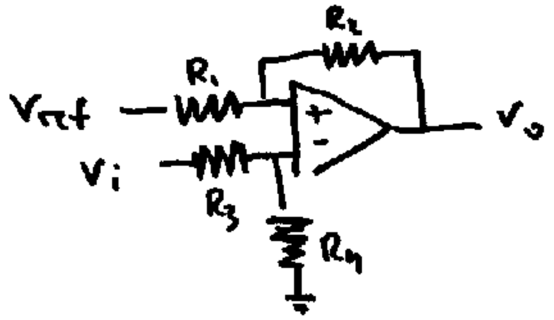
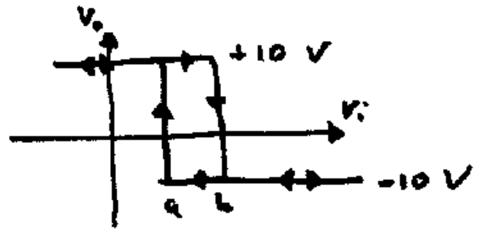
solution exame Instrumentation

9 / 07 / 2008 16:30

(1) see lecture notes

(2) 


a) Type I, because for $V_i = -\infty$ ; $V_o = +V_{cc}$

and for $V_i = +\infty$ : $V_o = -V_{cc}$

b) $\beta_1 = R_1/(R_1+R_2)$

$\beta_2 = R_4/(R_3+R_4)$

$V_p = \beta_1 V_o + (1-\beta_1) V_{ref}$

$V_n = \beta_2 V_i$

a : $V_o = -10$ , $V_i = a$ , $V_n = V_p$

$$-10\,\beta_1 + (1-\beta_1) V_{ref} = a\,\beta_2 \qquad (\mathrm{I})$$

b : $V_o = +10$, $V_i = b$, $V_n = V_p$

$$10\,\beta_1 + (1-\beta_1) V_{ref} = b\,\beta_2 \qquad (\mathrm{II})$$

II − I : $20\,\beta_1 = (b-a)\,\beta_2$

In this case $b = 2, a = 1$ =>

$$20\,\beta_1 = \beta_2$$

in II

$$10\,\beta_1 + (1-\beta_1) V_{ref} = 40\,\beta_1$$

$$V_{ref} = 30 \frac{\beta_1}{1-\beta_1}$$

$$(30 + V_{ref})\,\beta_1 = V_{ref}$$

$$\beta_1 = \frac{V_{ref}}{30 + V_{ref}}$$

. For example $V_{ref} = +5V$

$$\beta_1 = \frac{5}{35} = \frac{1}{7}$$

$$\beta_2 = 20\,\beta_1 = \frac{20}{7}$$ (not possible, $\beta_2 \le 1$)

(3)

a) see lecture notes

$$\frac{dR/R}{dL/L} = 1 + 2\nu + \frac{d\rho/\rho}{dL/L}$$

b) $\nu = 0.33$ , $\frac{d\rho/\rho}{dL/L} = 0$

$dL/L = 1\% \implies$

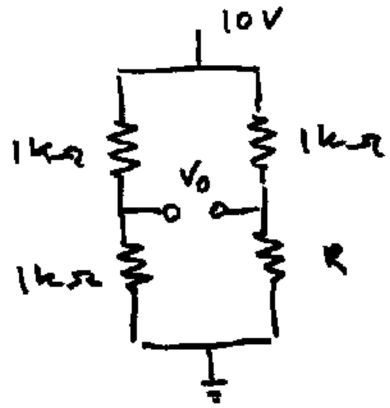
$$\frac{dR/R}{1\%} = 1 + 2 \cdot 0.33$$

$dR/R = 1.66\ \%$ , $R = 1k\Omega$

$\implies dR = 17\ \Omega$

$R = 1017\ \Omega$

c) $+1\% \to R = 1017\ \Omega$
$-1\% \to R = 983\ \Omega$

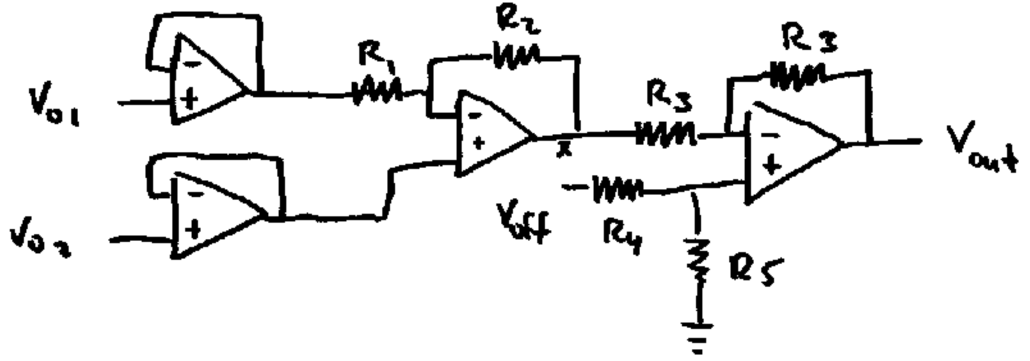



$$V_0 = 5V - 10 \cdot \frac{R}{R + 1k\Omega}$$

min $= 5 - 4.9571\ V$
$= 0.0429\ V$
max $= 5 - 5.0421\ V$
$= -0.0421\ V$

$\Delta V \sim 85\ mV$

We need an amplifier that has a gain of $\frac{5000}{85}$ and an offset so that for $V = -0.0421\ V$ the output is zero.




to put $r_{in} = \infty$

diff. amplifier

$$V_x = \frac{R_2}{R_1}(V_{o2} - V_{o1})$$

$$\frac{R_2}{R_1} = \frac{5000}{85}, \text{ ex.}$$

$50\,k\Omega$ & $850\,\Omega$

$-1\times$ amplifier plus offset ($r_{out} = 0$)

$$V_{out} = -V_x + \underbrace{\beta V_{off}}_{\text{should be } 2.5\text{ V}}.$$

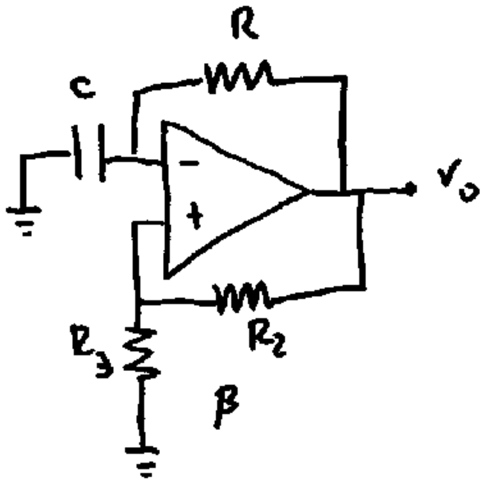
d) The ADC has 10 bit, so the number of levels is $2^{10} = 1024$.

The sensor and system are linear for (such) small perturbations.

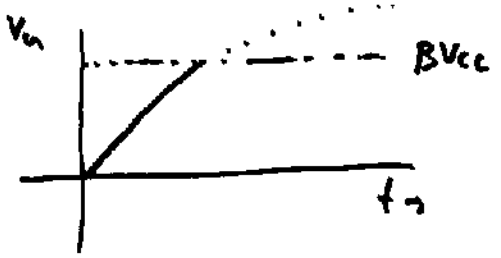
$$-1\% - +2\% = 2\% = 2\text{ mm}$$

resolution is $\frac{2\text{ mm}}{1024} \sim 2\,\mu m$

(4)

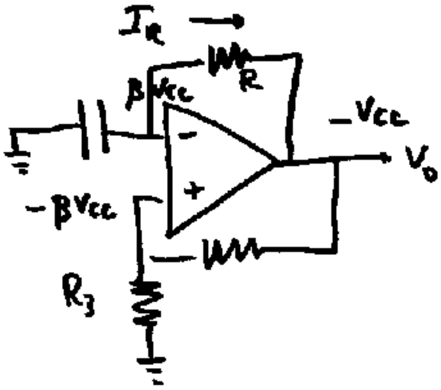



Imagine : $V_o = +V_{cc} \Rightarrow V_p = +\beta V_{cc}$ , $C$ is empty $\Rightarrow \Delta V_c = 0 \Rightarrow V_n = 0 \Rightarrow \Delta V_R = V_{cc} \Rightarrow I_R = \frac{+V_{cc}}{R}$ . This charges




C and $\Delta V_c$ will increase , until $V_n$ becomes larger than $+\beta V_{cc}$

At this moment the op amp commutes and we have the following situation



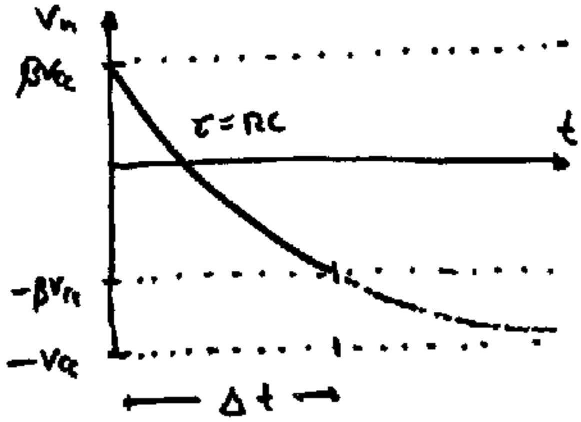

We set the time at $t=0$ . $I_R = \frac{\beta V_{cc} - (-V_{cc})}{R}$ will discharge the capacitor with a characteristic time $\tau = RC$ . (note that the charging /discharging current is not constant and the system has exponential behavior)

The discharging continues until $V_n < V_p$,

thus $V_n < -\beta V_{cc}$.

Thus, for $V_n$ we have

- $V_n(t=0) = \beta V_{cc}$
- $V_n(t=\infty) = -V_{cc}$
- commutes at $V_n = -\beta V_{cc}$
- $\tau = RC$




$$V_n(t) = -V_{cc} + (\beta+1)V_{cc}\exp(-t/RC)$$

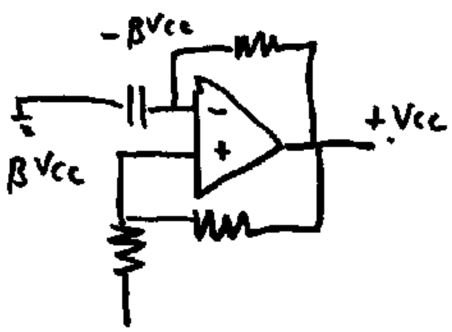
commutes at $t$:

$$-\beta V_{cc} = -V_{cc} + (\beta+1)V_{cc}\exp(-t/RC)$$

$$\Rightarrow$$

$$\Delta t = RC\ln\left(\frac{1+\beta}{1-\beta}\right)$$

At this moment we have the following situation:



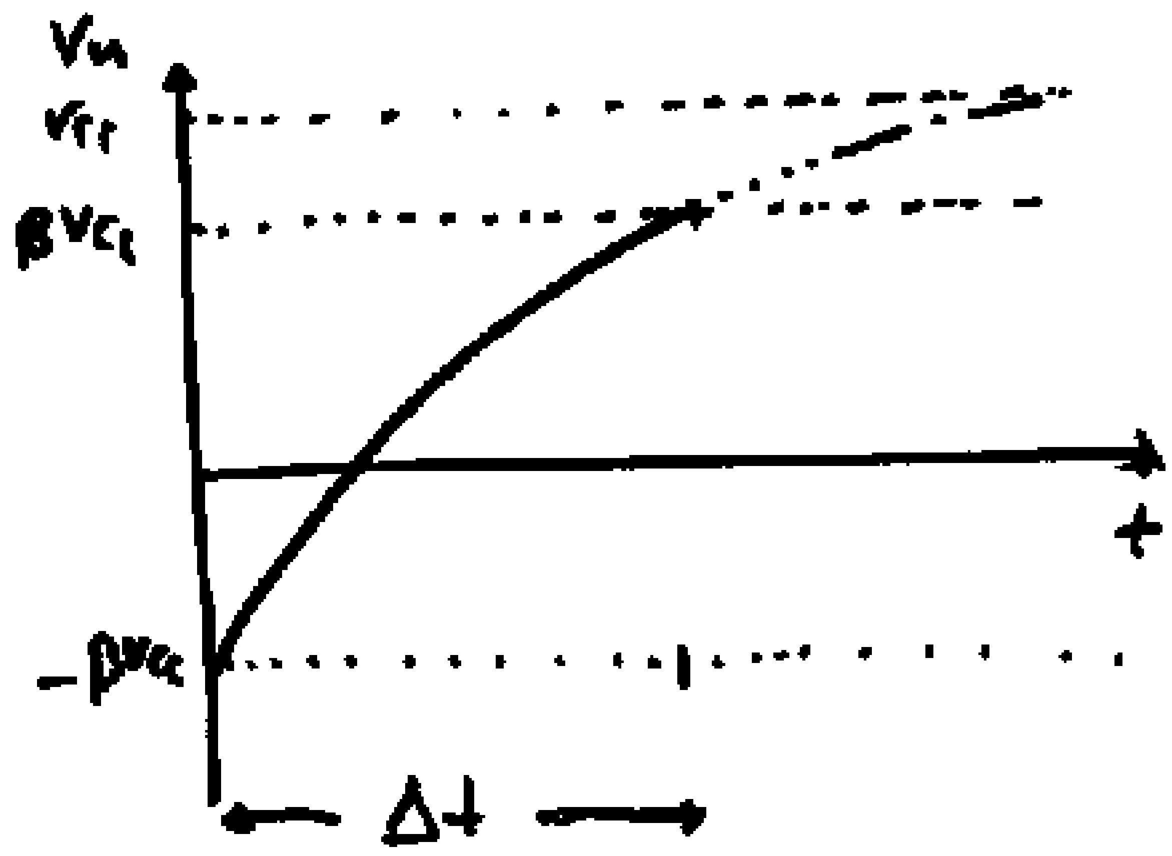

Again we set $t=0$. The current through R is discharging / charging the capacitor with a time constant equal to $\tau = RC$.

The charging continues until $V_n > V_p$,

thus $V_n > +\beta V_{cc}$.

Thus for $V_n$ we have

- $V_n(t=0) = -\beta V_{cc}$
- $V_n(t=\infty) = V_{cc}$
- commutes at $V_n = +\beta V_{cc}$
- $\tau = RC$




$$V_n(t) = V_{cc} - (\beta+1)V_{cc}\exp(-t/RC)$$

commutes when

$$\beta V_{cc} = V_{cc} - (\beta+1)V_{cc}\exp(-t/RC)$$

$$\Longrightarrow$$

$$\Delta t = RC\ln\left(\frac{1+\beta}{1-\beta}\right) \quad \text{(equal to other)}$$

The frequency is thus

$$f = \frac{1}{2\Delta t} = \frac{1}{2RC\ln\left(\frac{1+\beta}{1-\beta}\right)}$$

b) $f = 10$ kHz

$\beta = 1/3 \Rightarrow \ln\left(\frac{1+\beta}{1-\beta}\right) = \ln\left(\frac{4/3}{2/3}\right) = \ln 2$

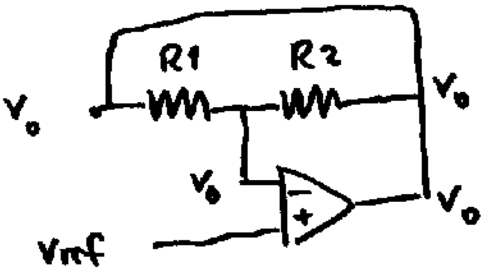
$C = 1$ nF

$$\Longrightarrow R = \frac{1}{10\text{ kHz} \cdot 2 \cdot 1\text{nF} \cdot \ln 2} = 72\text{ k}$$

(5) a) op-amp 2 is a tension follower,

thus at the $V_{p2}$ we have $V_0$

At op-amp 1 we thus have

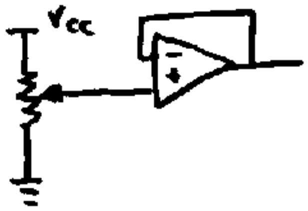



At $V_n$ we always have $V_0$ (because $r_{in} = \infty$)

$V_n = V_p = V_{ref} \Rightarrow V_0 = V_{ref}$

This circuit is just a fancy tension follower

b)




c) see sebenta

(6) A solar panel does not have information at its output (when used only as a powersupply)