Electronic Instrumentation Exam

5 - II - 2010

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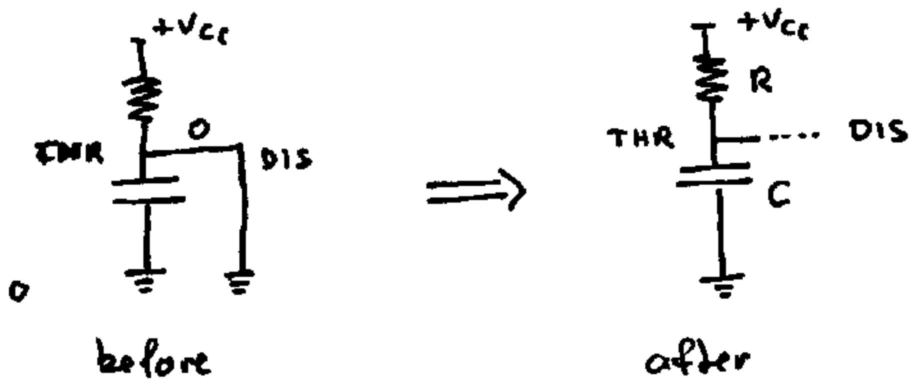
(1) when a (negative) pulse is received at the trigger input (TRI), the bottom comparator goes to high

if TRI < $\frac{1}{3} V_{cc}$

$S \to +V_{cc}$

This change low-high sets the flip flop output (out $\to +V_{cc}$) and $\bar{Q}$ becomes low. This cloces the "switch" (transistor) and the DIS line is effectively disconnected from ground. DIS $\to$ open circuit. We now have the following situation



The capacitor C, initialy discharged ($\Delta V = 0-0 = 0$) starts charging. Exponentially, $\tau = RC$, $V_c(t=0) = 0$, $V(t=\infty) = V_{cc}$.

$$V_{DIS} = V_{THR} = V_{cc}\left(1 - \exp(-t/RC)\right)$$

The capacitor continues being charged until this voltage becomes larger than VCON ($= \frac{2}{3} V_{cc}$)

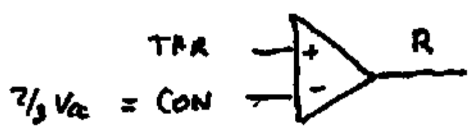
This takes place at a time when

$$V_{DIS} = V_{THR} = V_{CON}$$

$$V_{CC}\,(1 - \exp(-t/RC)) = 2/3\, V_{CC}$$

$$\Rightarrow t = RC \ln(3)$$

At this moment the top comapator goes from low to high

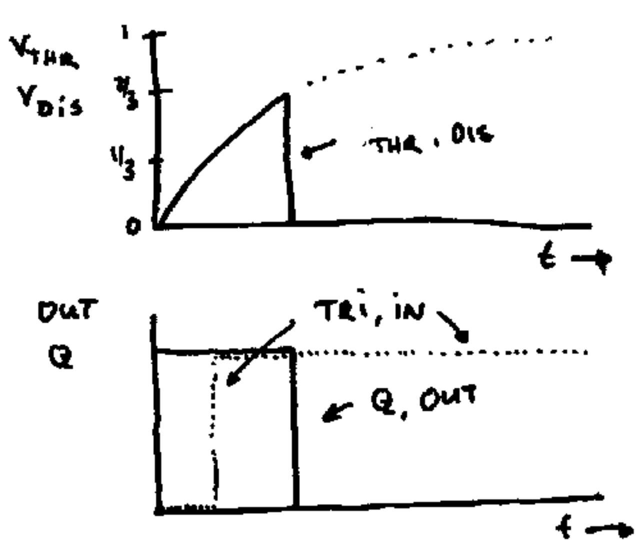


if THR > 2/3 Vcc
R → +Vcc

Note that the bottom comporator might still be high as well, but that is irrelevant; The flip-flop responds to changes and not to states.

The flip-flop thus is reset. out = Q → 0,

$\bar{Q}$ goes to high and the 'switch' transistor is opened, connecting the capacitor to ground, which is thus instantaneously discharged.



b) $RC \ln(3) = 1 \text{ ms}$

ex. $C = 1 \ \mu F$

$$R = \frac{1 \text{ ms}}{1 \ \mu F \ \ln(3)} = 910 \ \Omega$$

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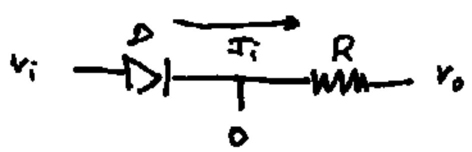
2 a) see lecture notes

- $r_{in} = \infty$
- $r_{out} = 0$
- $A = \infty \Rightarrow V_p = V_n$ (unless saturation)

b)



virtual ground
$(V_p = 0, \ V_n = V_p)$

$$I_i = I_0 \left[\exp\left(\frac{V_i}{V_T}\right) - 1\right]$$

This current cannot escape but through R

$$V_o = 0 - I_i R = -R I_0 \left[\exp\left(\frac{V_i}{V_T}\right) - 1\right]$$

c) $P_{out} = V_{out} \times I_{out} = -R I_0 \left[\exp\left(\frac{V_i}{V_T}\right) - 1\right] \times \left(-I_0 \left[\exp\left(\frac{V_i}{V_T}\right) - 1\right]\right)$

$$= R I_0^2 \left[\exp\left(\frac{V_i}{V_T}\right) - 1\right]^2$$

$V_i = -\infty \Rightarrow P_{out} = R I_0^2 = 10^{-26} \ W$. no problem!

forward bias:

$$P_{out} \approx R I_0^2 \left[\exp\left(\frac{V_i}{V_T}\right)\right]^2 = R I_0^2 \exp\left(\frac{2V_i}{V_T}\right)$$

$P_{max} = 10 \text{ mW} \Rightarrow V_{i\,max} = 0.69 \ V$

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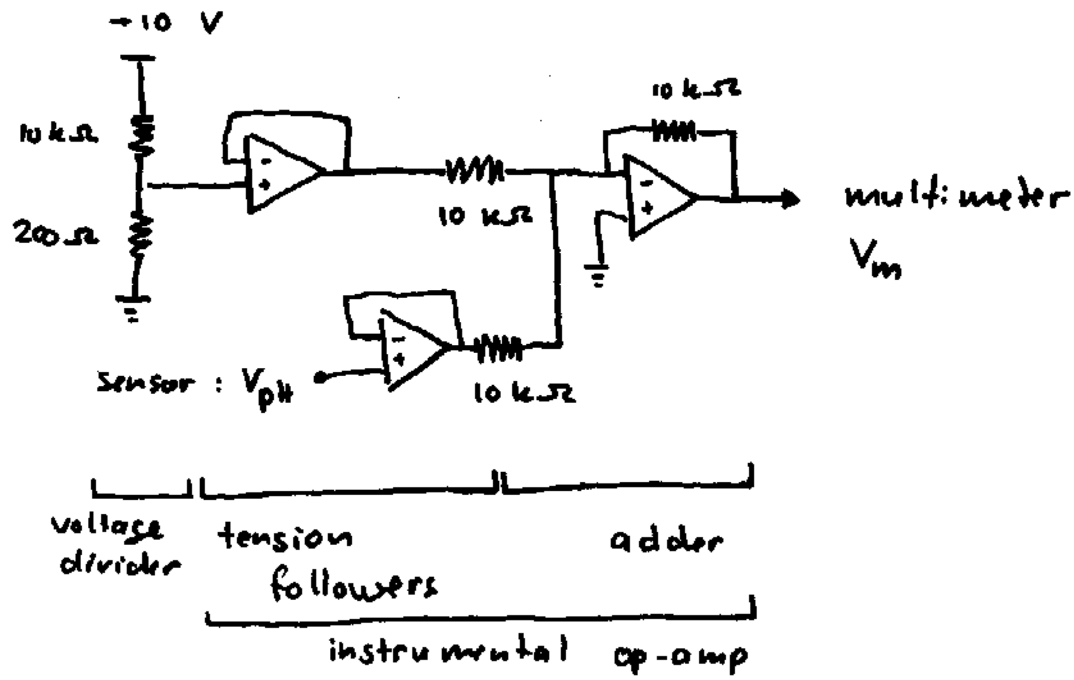
3 a) The signal at a pH of 5 is equal to +200 mV. To get highest resolution we have to subtract this voltage.



b) $\Delta N_{H^+} = \dfrac{\Delta V_m}{dV_m/dN_{H^+}}$, $\Delta V_m = 0{,}01$ mV

$$\frac{dV_m}{dN} = \frac{dV_m}{dpH} \cdot \frac{dpH}{dN} = \frac{dV_m}{dV_{pH}} \cdot \frac{dV_{pH}}{dpH} \cdot \frac{dpH}{d[N]} \cdot \frac{d[N]}{dN}$$

$$\frac{dV_m}{dV_{pH}} = 1 \quad \text{(see circuit above)}$$

$$\frac{dV_{pH}}{dpH} = 100 \text{ mV}$$

$$\frac{dpH}{dN} = \frac{1}{\ln(10)} \cdot \frac{1}{[N_{H^+}]}$$

$$\frac{d[N_{H^+}]}{dN_{H^+}} = \frac{1}{3\,l}$$

$$\frac{dV_m}{dN_{H^+}} = \frac{100 \text{ mV}}{\ln(10)} \cdot \frac{1}{[N_{H^+}]} \cdot \frac{1}{3\,l}$$

$$pH = 5 \Rightarrow [N_{H^+}] = 10^9 / liter$$

$$\frac{dV_m}{dN_{H^+}} = 1.45 \cdot 10^{-11}\,V \;/ atom\; H^+$$

$$\Rightarrow \quad \Delta N_{H^+} = \frac{10\,\mu V}{1.45 \times 10^{-11}\,V} \; atoms\; H^+ = 6.9 \times 10^5 \; atoms$$

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(4) see lecture notes

- thermo couple
- PT 100
- thermistor
- diode
- mechanical sensor
- spectrum analyzer

(5) see lecture notes