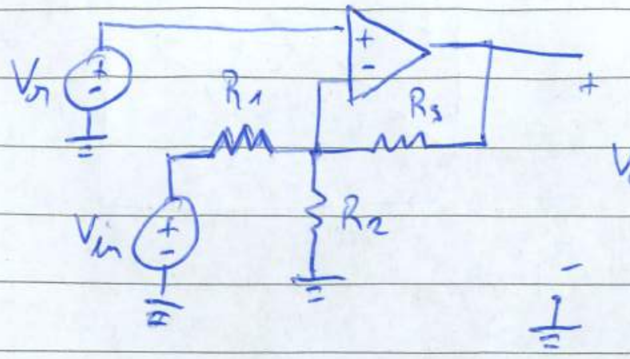
EXAM 1TE717 2018-08-20

B1:



$V_+ = V_r = V_-$

KCL on V- gives:

$$\frac{V_{in} - V_-}{R_1} - \frac{V_-}{R_2} - \frac{V_- - V_o}{R_3} = 0 \Leftrightarrow$$

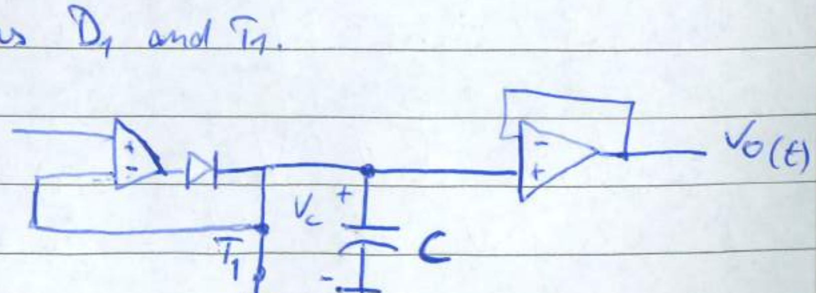
$$\frac{V_o}{R_3} = +\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)V_r - \frac{1}{R_1} V_{in} \Leftrightarrow$$

$$V_o = \left(1 + \frac{R_1 R_2 R_3}{R_1 + R_2}\right) V_r - \frac{R_3}{R_1} V_{in}$$

B2:

The key is to analyze the circuit for different states of the semiconductors D_1 and T_1.

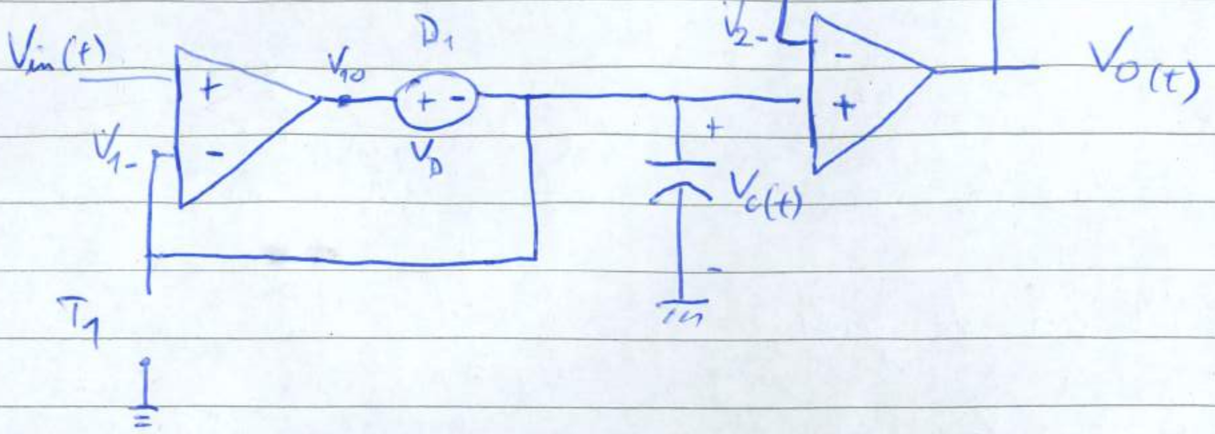
i) T_1 is ON:



The capacitor is short-circuited to ground, so $V_c = 0$ and $V_{o(t)} = V_c = 0$.

This happens independently of $V_{in}(t)$ and the state of D1. And this state is valid when $V_r(t) > 2V$

ii) T_1 is OFF & D_1 is ON:



Due to the negative feedback of the OpAmps:

$V_- = V_+ \implies V_{C(t)} = V_{1-} = V_{in}(t)$

$$V_{O(t)} = V_{2-} = V_C(t)$$

$$V_{O(t)} = V_{in}(t)$$

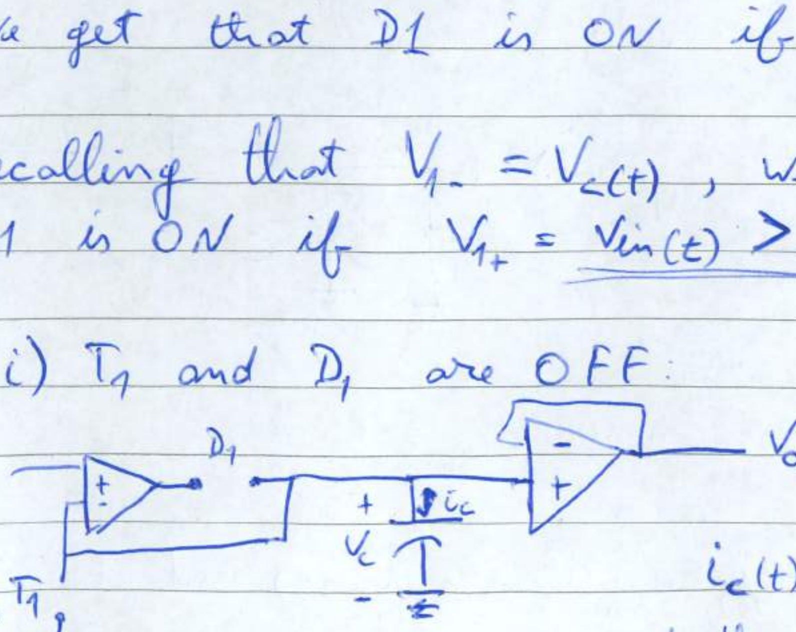
For this to be valid, we must have

$\underbrace{V_T(t) < V_{GS,th} = 2V}_{(T_1 \text{ OFF})}$ and $\underbrace{V_D = V_{10} - V_{C(t)} > 0.7V}_{(D_1 \text{ ON})}$

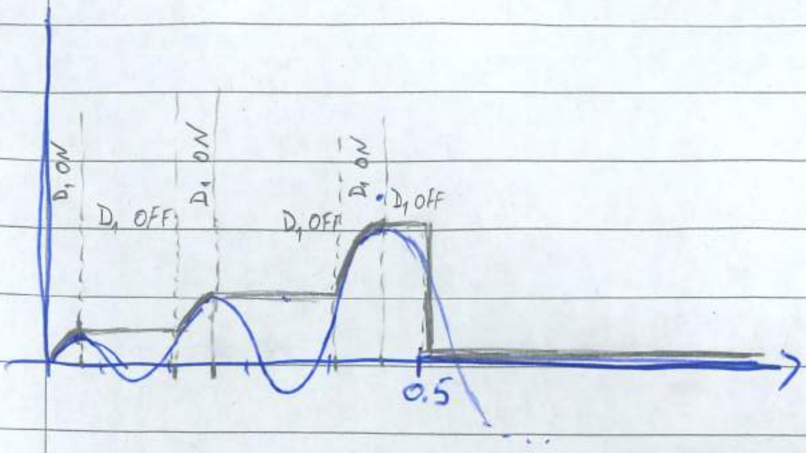
Since $V_{10} = A_{10}(V_{1+} - V_{1-})$ and $A_{10} \approx \infty$,
we get that D1 is ON if $V_{1+} - V_{1-} > \frac{V_{C(t)} + 0.7}{A_{10}} \approx 0$

Recalling that $V_{1-} = V_{C(t)}$, we conclude that
D1 is ON if $V_{1+} = \underline{V_{in}(t) > V_{C(t)}}$

iii) T_1 and D_1 are OFF:



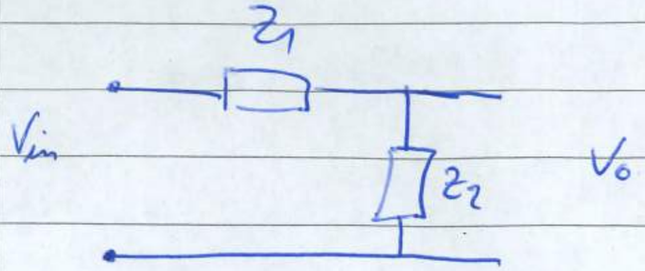
$i_c(t) = 0$, so $\frac{d}{dt}V_c(t) = 0$
and the voltage will be kept constant.



T_1 is OFF | T_1 is ON

B3

We want a BP filter. The filter will be of the form:



, ~~there~~ where Z_1 and Z_2 will be determined by arrangin one R, one L, and one C.

$$V_o = \frac{Z_2}{Z_1 + Z_2} V_{in} = H(j\omega) V_{in}$$

$Z_{eq} = Z_1 + Z_2$ is the total impedance, and it will remain the same regardless of how we arrange R, L and C.

$$Z_{eq} = R + \frac{1}{j\omega C} + j\omega L.$$

$$H(j\omega) = \frac{Z_2}{R + \frac{1}{j\omega C} + j\omega L}$$

BP filter means: $\underset{i)}{H(0) = 0}$, $\underset{ii)}{H(\infty) = \infty}$

i) $H(0) = \frac{Z_2}{R + \frac{1}{j\omega C} + j\omega L} \simeq \frac{Z_2}{\frac{1}{j\omega C}} = j\omega C Z_2 = 0$

This means Z_2 cannot have C in it!

ii) $H(\infty) = \frac{Z_2}{R + \frac{1}{j\omega C} + j\omega L} \simeq \frac{Z_2}{j\omega L} = 0$. so Z_2 cannot have L in it!

$\therefore\ Z_2 = R$