Answers to EEE210 final exam AY2016-2017

1. (a) i. Replace Zener diode by its model. Then show

$$V_{in} < 0 \Leftrightarrow \text{Zener forward biased}$$
$$0 < V_{in} < 9\ \text{V} \Leftrightarrow \text{Zener reverse biased off}$$
$$9\ \text{V} < V_{in} \Leftrightarrow \text{Zener reverse conduction}$$

The given V_{out} vs V_{in} is easily obtained.

ii. Zener diode is initially in reverse conduction. Then:

$$V_C(t) = 6 + 6\,\mathrm{e}^{-t/(2\ \text{ms})}\ \text{V}$$

The state of the diode changes at 1.386 ms.

(b) Depending on how you solve the problem you obtain

$$1810\ \Omega < R < 1995\ \Omega$$

and

$$3.35 \times 10^{-15}\ \text{A} < I_S < 3.78 \times 10^{-15}\ \text{A},$$

again, depending on how you solve.

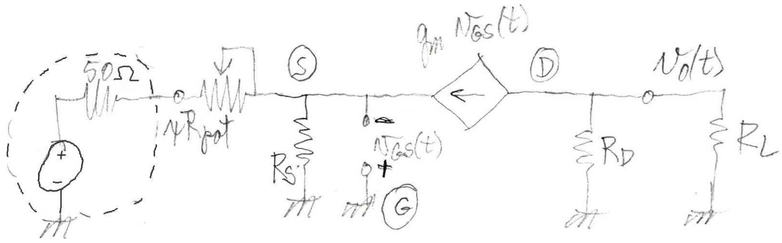
2. (a)

$$I_D = 2.646\ \text{mA}$$
$$V_{GS} = 2.23\ \text{V}$$
$$V_{DS} = 12.62\ \text{V}$$

(b)

$$R_E = 5.047619\ \text{k}\Omega$$
$$R_C = 4.5\ \text{k}\Omega$$

3. (a) The AC model is:



Use circuit analysis to obtain the voltage gain.

(b) Obvious from the above and $R_{\text{var}} = x\,R_{\text{pot}}$.

(c) $V_{GSQ} = 2.4286$ V, $I_{DQ} = 12.8571$ mA.

(d) $R_S = 330\ \Omega$.

(e) $R_D = 1\ \text{k}\Omega$.

(f) $V_{DSQ} = 7.89286$ V, $V_{GQ} = 6.67857$ V.

(g) $R_1 = 330\ \text{k}\Omega$, $R_2 = 120\ \text{k}\Omega$.

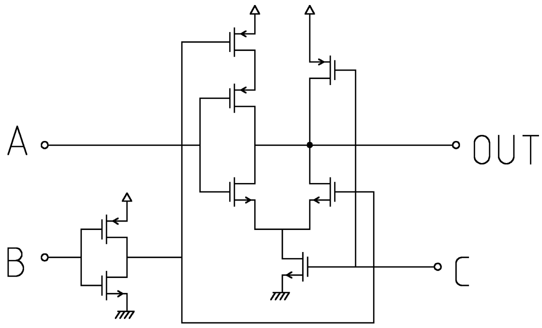
(h) Obvious from the above and $R_{\text{var}} = x\, R_{\text{pot}}$.

(i) $R_{\text{pot}} = 100\ \Omega$.

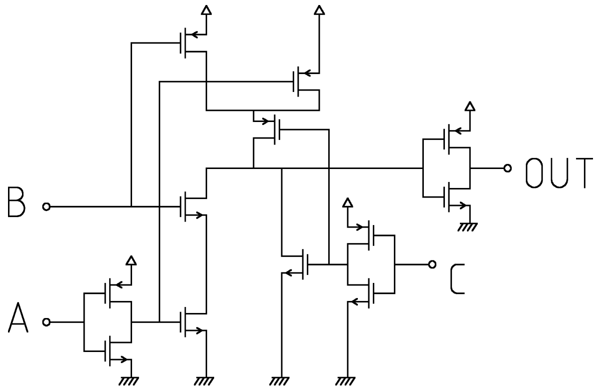
(j) $Z_{in} = (100\, x + 15.865)\ \Omega$.

(k) $Z_{out} = 1\ \text{k}\Omega$, $\forall x$.

4. (a) $\overline{A} \wedge B \vee \overline{C} = \overline{(A \vee \overline{B}) \wedge C}$ which leads to the circuit (requires 8 MOSFETs):



Alternatively, one can design the circuit for $\overline{\overline{\overline{A} \wedge B \vee \overline{C}}}$ and finish with an inverter as in the following (requires 12 MOSFETs):



(b) i. $v_{out} = -6.2 + 22.4\, v_{in} - 11.2\, v_{in}^2$

ii. $1 \text{ V} \le v_{in} \le 1.625 \text{ V}$

iii. Graphically we find values close to the ones below.

iv. $V_{iH} = 1.726874$ V, $V_{oL} = 0.38575827$ V, $V_{iL} = 1.0446429$ V, $V_{oH} = 4.9776786$ V. It follows that

$$NM_H = 3.2508046 \text{ V}$$
$$NM_L = 0.65888463 \text{ V}$$
$$NM = \frac{NM_H + NM_L}{2} = 1.954844615 \text{ V}$$