Answers to EEE210 final exam AY2014-2015

1. (a)

$$V_{out} = \begin{cases} 40 \text{ V} & \text{if } V_{in} < 40 \text{ V} \quad (D_1 \equiv \text{off and } D_2 \equiv \text{on}) \\ V_{in} & \text{if } 40 \text{ V} < V_{in} < 80 \text{ V} \quad (D_1 \equiv \text{on and } D_2 \equiv \text{on}) \\ 80 \text{ V} & \text{if } V_{in} > 80 \text{ V} \quad (D_1 \equiv \text{on and } D_2 \equiv \text{off}) \end{cases}$$

   (b) $V_D(0^+) = -2$ V $\Rightarrow$ D is initially *reverse biased*. D switches to *forward biased* at time $t_0 = 26.05$ ms. Finally:

$$v_o(t) = \begin{cases} 4.7 - 4.7\,\mathrm{e}^{-t/(47\text{ ms})} \text{ V} & \text{if } t \leq t_0 = 26.05 \text{ ms} \\ 2 \text{ V} & \text{if } t \geq t_0 = 26.05 \text{ ms} \end{cases}$$

2. (a) $R_1 = 150$ kΩ, $R_2 = 150$ kΩ, $R_S = 0.5$ kΩ, $R_D = 0.5$ kΩ.

   (b) $g_m = 10$ m℧

   (c) Set all DC sources to 0, replace all capacitors by short-circuits, replace the MOSFET by its small signal AC model with:

$$g_m = 10 \text{ m℧}$$

   and redraw.

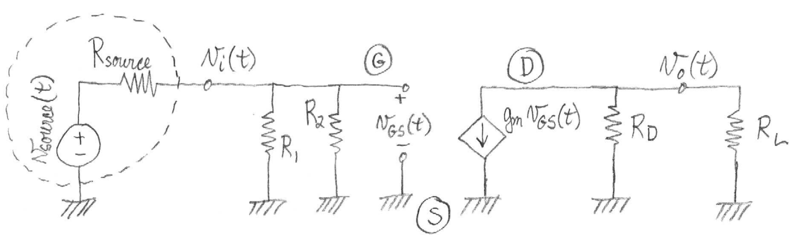

Figure 1:

   Voltage gain expression is easily obtained; refer to course notes. We find $A_V = -3.33$.

   (d) $Z_{in} = 75$ kΩ.

   (e) $Z_{out} = 500$ Ω.

   (f) $R_L = Z_{out} = 500$ Ω.

3. (a) $R_E \triangleq R_{E1} + R_{E2} = 1.1589$ kΩ, $R_C = 3.5$ kΩ.

   (b) $R_1 = 104.35$ kΩ, $R_2 = 24.742$ kΩ.

   (c) Set all DC sources to 0, replace all capacitors by short-circuits, replace the BJT by its small signal AC model and redraw ($h_{ie} \approx 1.5$ kΩ from the graph).

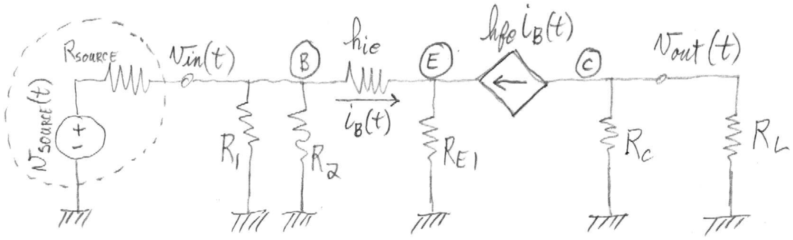

Figure 2:

(d) Easy; refer to course notes.

(e) $R_{E1} = 505\ \Omega$, $R_{E2} = 654\ \Omega$.

(f) $Z_{in} = 15.88\ \text{k}\Omega$, $Z_{out} = 3.5\ \text{k}\Omega$, $A_P = 39.7$.

(g) $-1.55\ \text{V} < v_{in}(t) < 1.64\ \text{V}$.

4. (a) Easy.

(b) i. $t_0 = 4.286$ ns

ii. 3.365 ns

iii. 7.650 ns

iv. A.

$$\begin{aligned} t_1 &= R_{eq} C \ln(2) \\ &= 6.93147 \times 10^{-12}\, R_{eq} \end{aligned}$$

B. $R_{eq} = 1.104\ \text{k}\Omega$.