National Tsing Hua University
Department of Physics

PHYS3090 **Applied Electronics I** **108 Spring**

Final Exam

注意：每個答案皆要有嚴謹的推導過程或詳細的推論理由。考題總分為 121 分。

1. (15 points) In Figure 1, $R_1 = 240\text{k}\Omega$, $R_2 = 160\text{k}\Omega$, $R_C = 3.2\text{k}\Omega$, $R_{E1} = 100\Omega$, $R_{E2} = 1.5\text{k}\Omega$, and $V_{CC} = 20\text{V}$. The transistor in the active region has $\beta_{DC} = \beta_{ac} = 100$, $V_{BE} \approx 1.0\text{V}$, and negligible r_e'. When $V_s = 0$, what are V_B (the voltage at the base), I_C (current flowing into the collector) and V_{CE} (the collector-emitter voltage)?

2. (20 points) Follow problem 1. (a) Please find the input and output impedances of the circuit (excluding V_s and R_L). (b) When $V_s = 20\sin(\omega t)$ mV and $R_L = 320\text{k}\Omega$, what is V_L (voltage across R_L)? (c) When $V_s = 10\sin(\omega t)$ mV and $R_L = 3.2\text{k}\Omega$, what is V_L?

3. (20 points) In Figure 2, $R_1 = 12\text{k}\Omega$, $R_2 = 8\text{k}\Omega$, $R_E = 200\Omega$, and $V_{CC} = 20\text{V}$. The two transistors are the same and, in the active region, they have $\beta_{DC} = \beta_{ac} = 30$, $V_{BE} \approx 1.0\text{V}$, and negligible r_e'. (a) When $V_{in} = 0$, what are V_{B1} (the voltage at the base of Q_1), I_E (current flowing through R_E), and V_{CE2} (the collector-emitter voltage of Q_2)? (b) When $V_{in} = 5\sin(\omega t)$ V, what is I_{b1} (ac current flowing into the base of Q_1)?

4. (20 points) In Figure 3, $R_1 = 2\text{k}\Omega$, $R_2 = 2\text{k}\Omega$, $R_L = 8\Omega$, and $\pm V_{CC} = \pm 15\text{V}$. The two transistors Q_1 and Q_2 all have $\beta_{DC} = \beta_{ac} = 40$, $V_{BE} \approx 1.0\text{V}$, and $r_e' = 2\Omega$. The input signal is $V_s = 12\sin(\omega t)$ V. What are the average power consumptions of Q_1, R_L, the entire amplifier (including R_L and excluding $\pm V_{CC}$)? What is the average power provided by V_s?

5. (10 points) An audio amplifier has input and output impedances of $10\text{k}\Omega$ and 50Ω, and a voltage gain of 1,500. The amplifier's input connects to a detector and its output connects to a recorder. The detector has an output impedance of $5\text{k}\Omega$, and produces a voltage signal of $1.2\sin(\omega t)$ mV without any load (i.e., without connecting to the amplifier). The recorder has an input impedance of 50Ω. What is the signal received by the recorder?

6. (10 points) The drain-source voltage V_{DS} and drain current I_D of JFETs has the following typical relationship: $I_D = I_{D(\text{sat})}\left(1 - e^{-V_{DS}/V_0}\right)$, where $I_{D(\text{sat})} = I_{DSS}\left[1 - \left(V_{GS}/V_{GS(\text{off})}\right)\right]^2$. A given JFET, which is used as a voltage-controlled variable resistor shown in Figure 4, has $V_0 = 5\text{V}$, $I_{DSS} = 100\text{mA}$, and $V_{GS(\text{off})} = -5\text{V}$. Define the resistance of the variable resistor as R_V. Under the condition of $V_{DS} \ll 5\text{V}$, what are the values of R_V at $V_{GS} = -4\text{V}$ and $V_{GS} = 0$?

7. (10 points) Refer to Figure 5. Which mode (depletion, enhancement, or neither) is each D-MOSFET biased? In each circuit, what are the sign (positive or negative) of V_{GS} and the direction (flowing into or out of the drain) of I_D?

8. (Total 16 points) [a] (8 points) 請以元件的構造圖與電荷分佈，說明 p-channel JFET 的如何以電壓控制電流的原理，要標示電壓的正或負極性及電荷是電子或電洞。[b] (8 points) 請以元件的構

造圖與電荷分佈，說明 *p*-channel E-MOSFET 如何以電壓控制電流的原理，要標示電壓的正或負極性及電荷是電子或電洞。

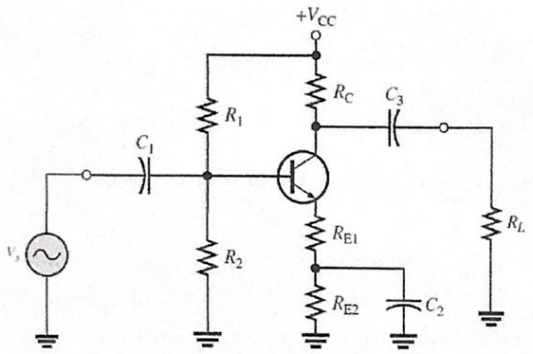

Figure 1

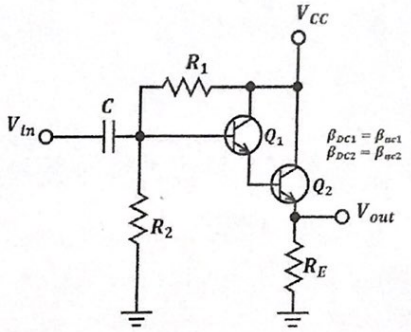

Figure 2

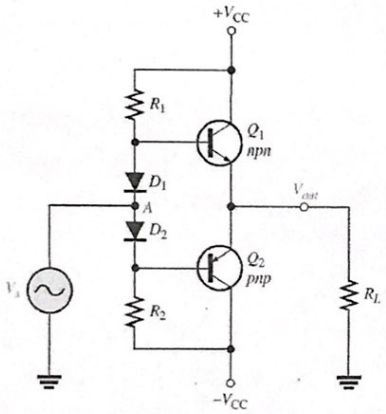

Figure 3

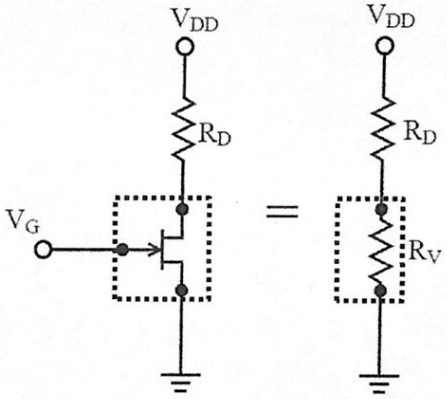

Figure 4

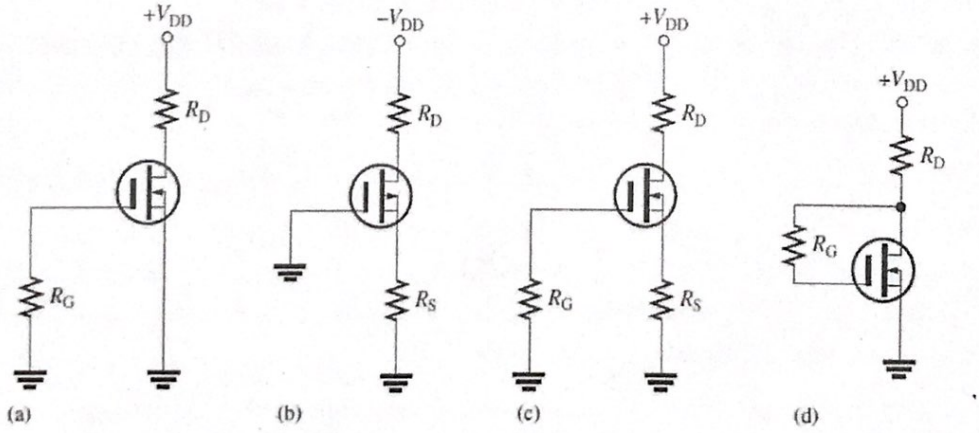

Figure 5