※注意：作答時，請於答案卷上標明作答之部分及其題號。

Part I　計算與問答題 (60% total)

1. (25%) Consider the difference amplifier in Figure 1a. (a) Use superposition to derive v_O as a function of v_1 and v_2 (5%). (b) It is common to express the output voltage in the form $v_O = G_d\, v_d + G_{cm}\, v_{CM}$, where G_d is the differential gain and G_{cm} is the common-mode gain, respectively, as shown graphically in Figure 1b. Use your formula derived in part (a), find the expressions for G_d and G_{cm}, and then derive the common-mode rejection ratio (CMRR) of the closed-loop amplifier (8%). (c) Normally, the circuit is designed with $R_1/R_2 = R_3/R_4$. Compute the differential voltage gain G_d when $R_1/R_2 = R_3/R_4$ (4%). (d) In reality however, inaccuracy in the resistors results in finite CMRR. Show that if each resistor has a small inaccuracy of ε (i.e., for a 5% resistor, $\varepsilon = 0.05$), then the worst-case CMRR is given approximately by CMRR = 20 log $[(G_d + 1)/4\varepsilon]$ (8%).

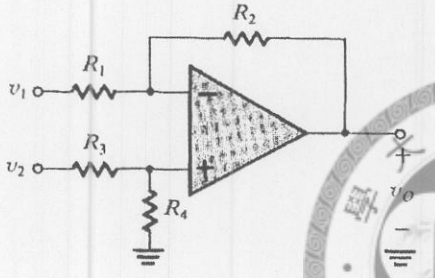

Figure 1a

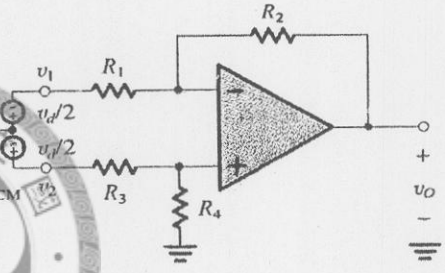

Figure 1b

2. (15%) Given the Wien-bridge oscillator in Figure 2, derive the loop gain $L(s)$ analytically (5%). Compute the resistance R at an oscillation frequency of 1.0KHz, if using two 16nF capacitors (5%). What criteria on R_1 and R_2 must be met to ensure starting of oscillation (5%)?

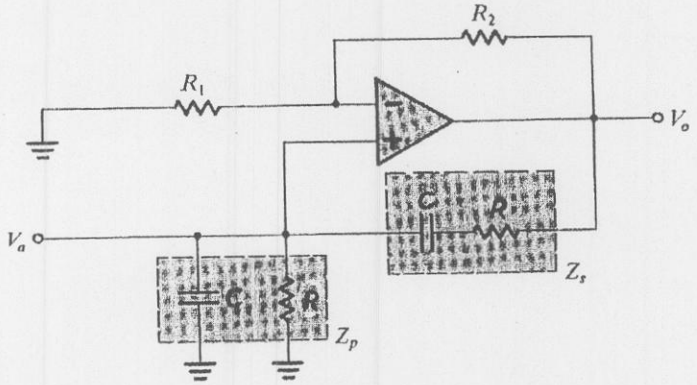

Figure 2

3. (20%) (a) Sketch the circuit of an active-loaded NMOS differential amplifier (differential-in, single-ended out) in which the input transistors are cascoded, and a PMOS cascode current mirror is used for the load. Remember to include the symbol of an ideal current source for biasing (10%). (b) Derive the differential voltage gain as a function of DC gate-to-source operating voltage V_{GS}, threshold voltage V_t, and Early voltage $|V_A|$, assuming all transistors have equal $|V_A|$ and all are operated at the same effective voltage (10%).

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Part II. 選擇題 (20% total, 4% each)

4. (4%) Choose one single incorrect statement about BJT transistors: (A) The base is often made very thin, with thickness on the order of the width of the depletion region. (B) The base is often doped with relatively dilute impurity. (C) The base-emitter junction is often made large for efficient emission of charge-carriers. (D) Biasing of a single BJT transistor for analog amplifiers is often done such that the BJT operates in the active region.

5. (4%) Choose one single correct statement about analog MOS amplifiers: (A) The common-source amplifier suffers from relatively low bandwidth because of the Miller effect which magnifies the gate-to-source capacitance. (B) The common-drain-common-source cascade amplifier increases the bandwidth via a reduction of the Miller capacitance of the common-source amplifier. (C) The common-source-common-gate cascode amplifier increases the bandwidth via a reduction of the resistance seen from the gate of the common-source amplifier. (D) The differential voltage gain of the common-source differential amplifier suffers from relatively low bandwidth due to similar Miller effect as in single-transistor common-source amplifier.

6. (4%) Choose one single correct statement about feedback: (A) Negative feedback decreases the 3dB bandwidth of the closed-loop gain. (B) Negative feedback using passive elements decreases the sensitivity of closed-loop gain to the gain of the amplifier. (C) Frequency compensation used in amplifier ICs increases open-loop bandwidth to achieve better stability when used in closed-loop circuits. (D) Shunt-shunt feedback is the proper feedback scheme for transconductance amplifiers.

7. (4%) Which of the following output stage configurations shows the highest power conversion efficiency when the output signal is at its largest possible voltage swing? (A) class A, (B) class B, (C) class AB, (D) no basis for such a comparison.

8. (4%) Choose one single correct statement: (A) Every Op-Amp has a stage that converts differential signal to being single-ended (i.e., signal relatively to ground potential) in its internal circuit. (B) In general situations an Op-Amp can be constructed using entirely NMOS transistors as the analog amplifier elements (excluding current-source transistors) to maximize voltage gain. (C) All Op-Amps must have frequency compensation built-in in the internal circuits. (D) CMOS Op-Amps do not need efficient output-stage configurations in the internal circuits.

Part III 解釋名詞 (20% total, 5% each. Note: Not just "Chinese translations". You need to briefly tell me their functions/usages/characteristics to convince me that you really understand them.)

9. (5%) Monostable multivibrator

10. (5%) EEPROM

11. (5%) Flash analog-to-digital converter

12. (5%) Unit-gain bandwidth