

※ 考生請注意：本試題可使用計算機。請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. (12%) Please explain following terminologies:
 - a) frequency response, b) current mirror, c) differential gain and common-mode gain, d) Zener diode.
2. (15%) For the two-stage CMOS operational amplifier as shown in Figure 1, please derive the voltage gain and the common-mode rejection ratio of this CMOS operational amplifier.
3. (8%) Please derive the relationship of I_O/I_{REF} of the Widlar current source as shown in Figure 2.
4. (5%) Please explain why we need to use instrumentation amplifier in measuring bioelectrical signal?
5. (10%) Please draw the circuit of common-based (CB) amplifier and derive its input and output resistance.
6. (15%) The concentration profile of a *npn* BJT is shown in Figure 3. Please derive proof that

$$i_C = Aqn_i^2 \left(\frac{D_p}{L_p N_D} + \frac{D_n}{L_n N_A} \right) (e^{V/V_T} - 1).$$

Note that $p_n(x_n) = p_{n0}e^{V/V_T}$,

$$n_p(0) = n_{p0}e^{V_{BE}/V_T}$$

$$\text{excess concentration} = p_{n0}e^{V/V_T} - p_{n0} = p_{n0}(e^{V/V_T} - 1).$$

7. (10%) Please Find the output resistance of the double-cascode current mirror of circuit shown in Figure 4.
8. (10%) BJT is also utilized in the logic gate realization. Please verify the logic functions (AND, OR, NOR, NAND) in the two circuits in Figure 5 and explain your reason.

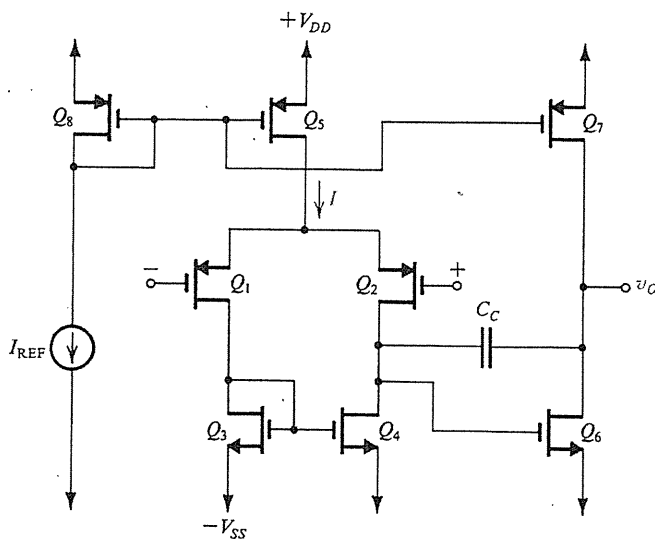


Figure 1

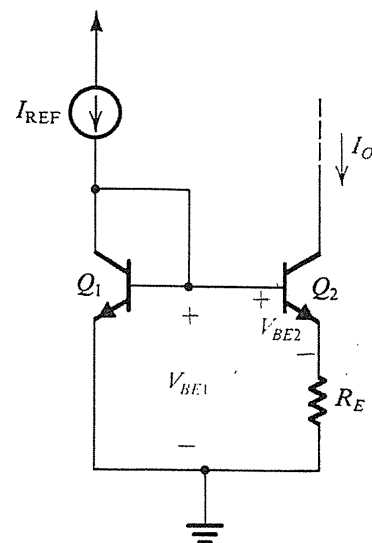


Figure 2

9. (15%) The charge density (ρ) that stored in the depletion region of a pn junction can be expressed as Figure 6. The width of depletion layer in the p region is x_p , and the width of depletion layer in the n region is x_n . Please try to derive the that the build in voltage (v_{bi}) can be expressed as follows: $V_0 = V_{bi} = V_T \ln\left(\frac{N_A N_D}{n_i^2}\right)$.

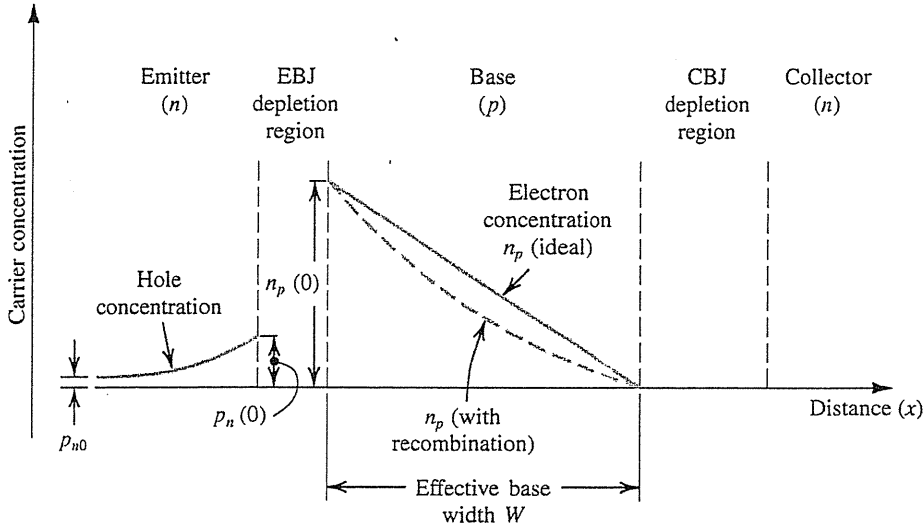


Figure 3

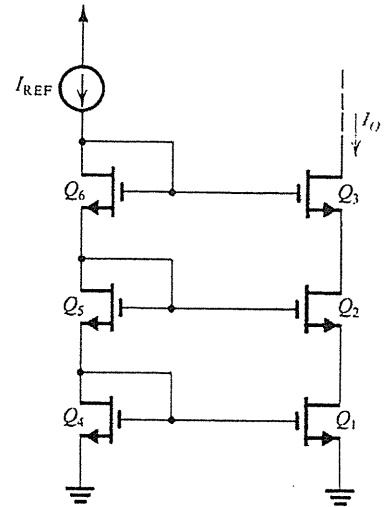


Figure 4

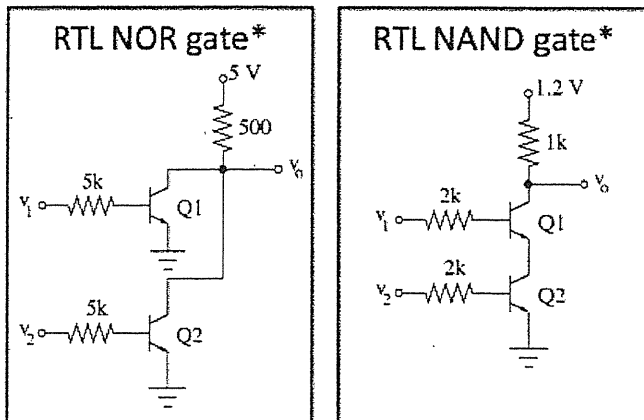


Figure 5

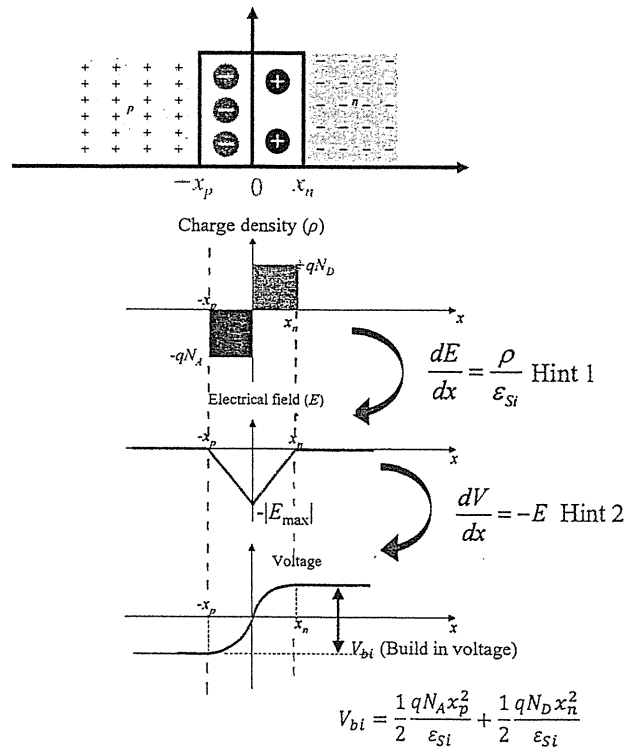


Figure 6