

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

1. (15%) Please explain following terminologies generally used in microelectronics:
a) doped semiconductor, b) *pn* junction, c) Early effect, d) channel length modulation, e) common mode rejection ratio (CMRR).
2. (15%) An instrument amplifier is shown in Figure 1, please derive the differential gain A_d ($A_d \equiv v_o/v_{id}$, where $v_{id} = v_{I2} - v_{I1}$) of the instrument amplifier.
3. (15%) The circuit shows in Figure 2 has a 2-to-4 decoder with active high outputs connected to a 4-to-1 MUX with an active low output. Please derive a minimum SOP or a minimum POS expression for the output $f(A, B, C, D)$.
4. (15%) Please find the input resistance (R_{in}) of the CB amplifier as shown in Figure 3 (please include the effect of finite output resistance r_o).
5. (20%) Please draw the high-frequency equivalent circuit model and find the frequency of poles of the CC-CB amplifier as shown in Figure 4 (Hint: please take C_π and C_μ into your analysis).

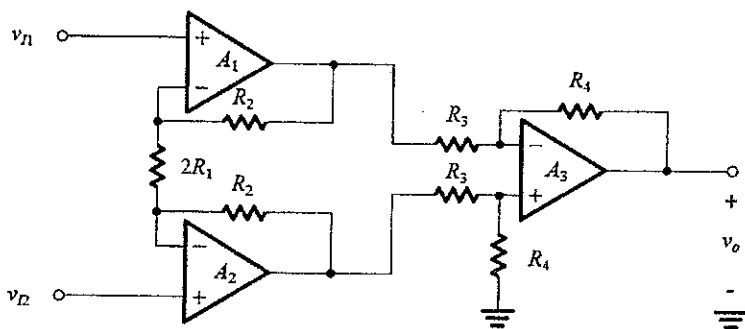


Figure 1

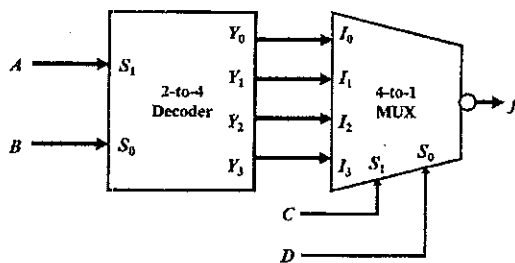


Figure 2

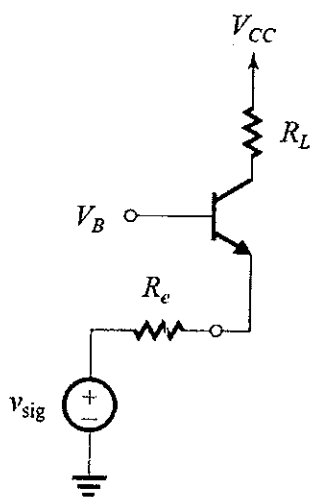


Figure 3 CB amplifier

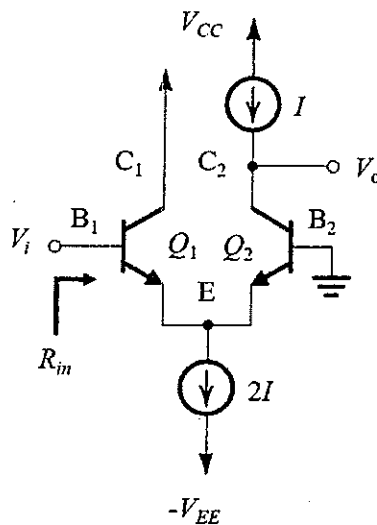


Figure 4 CC- CB amplifier

6. (10%) Transfer function of a second-order low-pass filter can be expressed as Eq. (1) and the magnitude response is shown in Figure 5, please derive that $\omega_{\max} = \omega_0 \sqrt{1 - \frac{1}{2Q^2}}$.

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$$T(s) = \frac{a_0}{s^2 + s\frac{\omega_0}{Q} + \omega_0^2} \quad \text{Eq. (1)}$$

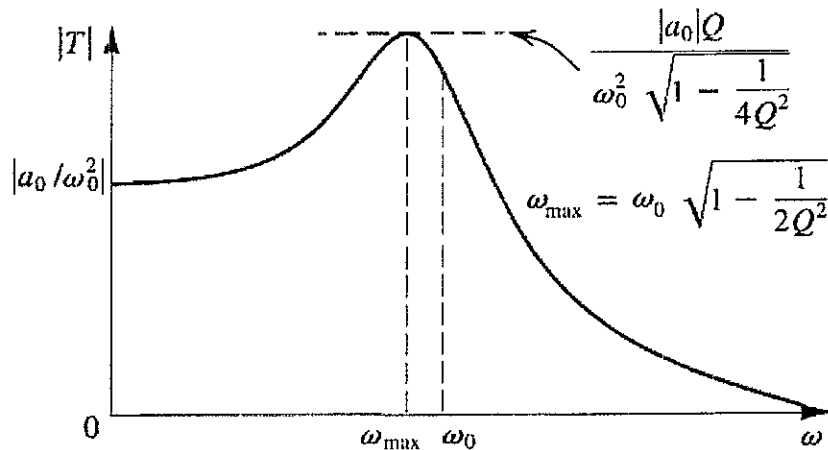


Figure 5

7. (10%) Photoplethysmography (PPG) is widely used in hospital especially for pulse rate and SpO₂ measurement. Please use anything you learned in your undergraduate study to design a system that can collect PPG and convert analogue signal into digital data. Please explain how many parts (ex. amplifier, filter...) will be adopted and details of each parts (circuits/schematics/solutions you will adopt) in your design.