

※ 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。

- (15%) Please explain following terminologies:
a) diffusion and drift, b) *p*-type silicon, c) body effect, d) Miller's theorem, e) Cascode.
- (5%) The structure of a *Si* crystal cell is shown in Figure 1. In this cell, there are 4 atoms completely inside cell, each of the 8 atoms on corners are shared among cells, and each of the 6 atoms on the faces are shared among 2 cells. The length of each cell is 0.543 nm. Please calculate the density (number of atoms / cm³) of silicon atoms.
- (10%) Please draw the circuit diagram of an *N*-input weighted summer by using operational amplifiers and resistors, derive the output of weighted summer in term of *N*-input ($v_1, v_2 \dots v_N$) and weighted gain.
- (10%) Please draw the circuit of a Cascode amplifier with a Cascode current-source load and find voltage gain (v_o/v_i).
- (15%) Please derive the transfer function and draw the frequency response of a common-emitter (CE)(as shown in Figure 2) amplifier in low-frequency band, mid-gain band, and high-frequency band.
- (15%) Please draw the circuit of the MOSFET differential amplifier and derive the common mode rejection ratio (CMRR) when resistor (R_{D1} and R_{D2}) from drain to power supply (V_{DD}) are mismatch.
- (10%) Please draw the circuit diagram of the emitter follower and derive the overall voltage gain, input resistance, output resistance of the emitter follower.
- (10%) Show that for a *pn* junction reverse biased with a voltage V_R , the depletion-layer width W and the charge stored on either side of the junction Q_J , can be expressed as:

$$W = W_0 \sqrt{1 + \frac{V_R}{V_0}}, \quad Q_J = Q_{J0} \sqrt{1 + \frac{V_R}{V_0}}$$

where W_0 and Q_{J0} are the values in the equilibrium

- (10%) Electrocardiogram (ECG) is widely used in hospital especially for heart rate detection or cardiac disease diagnosis. Please use anything you learned in your undergraduate study to design a system that can measure ECG and can count heart rate by analog circuit. Please explain how many parts (ex. amplifier, filter...) will be adopted and details of each parts in your design.

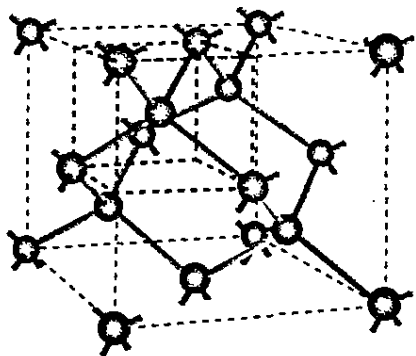


Figure 1

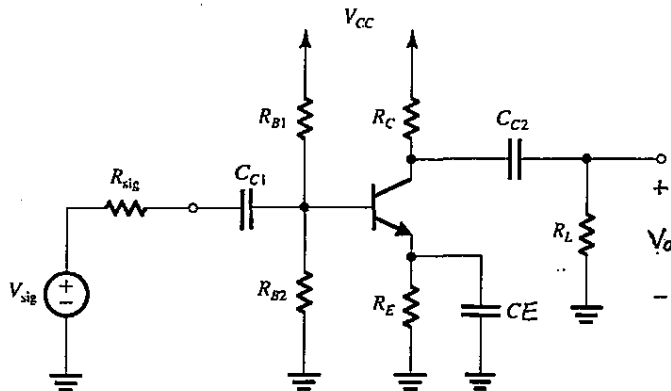


Figure 2