國立臺灣海洋大學一0二學年度研究所碩士班暨碩士在職專班招生考試試題

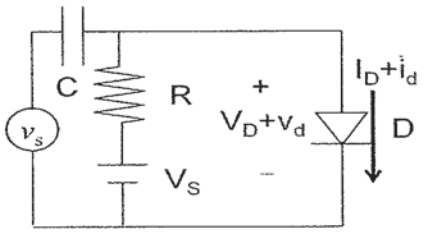
考試科目： 電子學（含半導體元件物理）

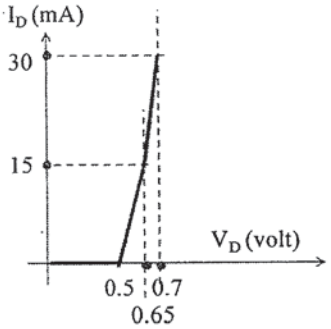
系所名稱： 電機工程學系碩士班固態電子組 ※可使用計算器

1.答案以橫式由左至右書寫。2.請依題號順序作答。

註 1：請配合將各大題作答在同一區塊並標明題號(如 1(a)、3(b)...)
註 2：重要參數或計算值請參酌
註 2：可使用計算機

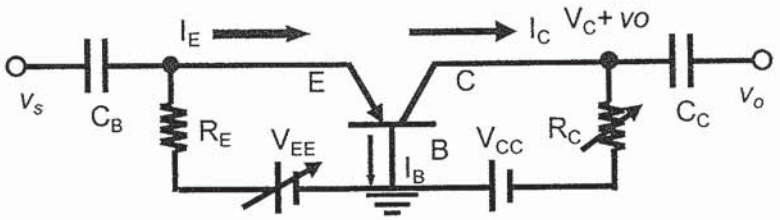
1、Give a resistor-diode circuit with I-V characteristics of the diode shown as follows. Where C is large enough for small signal v_s. $V_D(I_D)$ and $v_d(i_d)$ are from Vs and v_s, respectively.
(a) If V_S=3 volt, v_s=0, and R=240Ω, find the current flowing through the diode. 2%
(b) If V_S=3 volt, v_s=2sin(wt) milli-volt and R=240Ω, find the current flowing through the diode. 3%
(c) If V_S=5 volt, v_s=2sin(wt) milli-volt and R=200Ω, find the current flowing through the diode. 5%



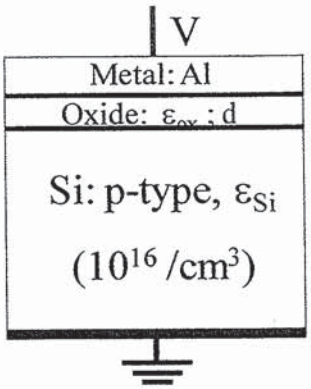


2、For a Si p-n junction diode with the p- and n-side doped with 10^{16} B atom/cm^3 and 2×10^{16} As atom/cm^3, respectively. When the diode is reverse-biased by a voltage of V_R, the depletion width found on the n-side is 0.5 micron. Then
(a) Determine the built-in voltage associated with the diode at equilibrium. (Intrinsic concentration n_i=10^{10} /cm^3) 2%
(b) Determine the depletion width on the p-side of the diode at V_R (F/cm^2). 2%
(c) Find the depletion capacitance C_T of the diode at V_R. 2%
(d) Calculate the bias voltage V_R. 2%

3、A voltage amplifier is shown as follows. For the bipolar transistor, the on-voltage of emitter-base junction is fixed at 0.7 volt and the saturation voltage between the emitter and collector is ≈0.2 volt. Knowing that V_{EE}=1.7 volt, V_{CC}=6 volt, and R_E=0.5 kΩ.
(a) What kind of the transistor, n-p-n or p-n-p? 2%%
(b) If the common emitter current gain β_F=99, determine the common-base current gain α_F. 2%
(c) With a known α_F=0.95, determine V_C and I_C for R_C=2 kΩ and v_s=0 volt. 3%
(d) Along with problem (c), if v_s=2.5cos(wt) milli-volt find the v_o=?3%
(e) Assuming the base transport factor is idealized (α_T≈1) with an emitter injection efficiency of γ=0.98, determine the voltage gain A_v, input and output resistance (R_i and R_o) for R_C=2 kΩ. 5%

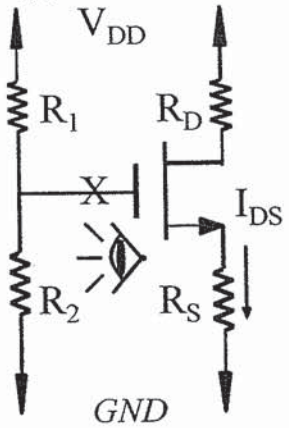


4、For an Al-SiO_2-Si MOS diode shown as follows on the left hand side, the voltage across the Si-substrate occurring strong inversion is $V_{Sub} \approx 0.7$ volt.
(a) Find the maximum depletion width, W_{max}, of the Si-substrate. [See hint] 2%
(b) For a d=14 nm, calculate the value of the capacitor, C_{ox} (F/cm^2). 2%
(c) Along with problems (a) and (b), determine the threshold voltage V_T that results in strong inversion. 2%
(d) If V_T=5 V is required, find the new value of oxide thickness d'. 4%



$$H\,\text{int}: V_{Sub} = \frac{qN_A W^2}{2\varepsilon_{Si}}$$

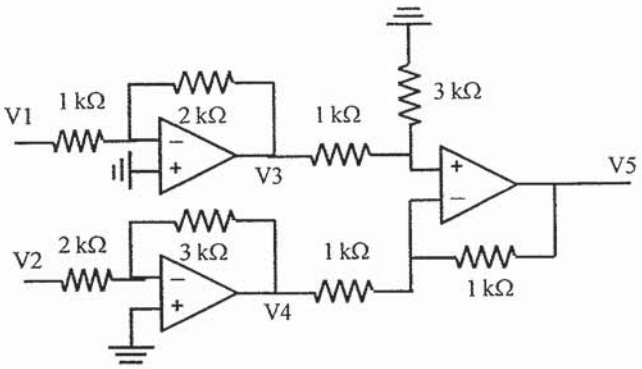
$$I_{DS} = k_n \frac{W}{L}(V_{GS} - V_T)^2$$

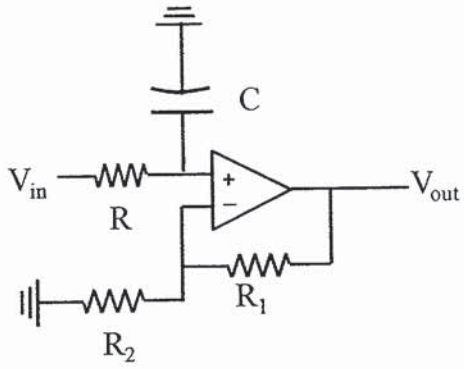


5、Enhancement-mode MOSFET circuits biased as a discrete-component amplifier is shown above on the right hand side with saturation current expression. Where k_n=50 μA·V^{-2}, W/L=10, and V_T=1 volt, V_{DD}=6 volt, R_1=R_2=1 MΩ, **R_D=2R_S**=4 kΩ.
(a) Find the Thevenin's equivalent circuit left seeing from marker "X", V_{th} and R_{th}. 4%
(b) Using the result in (a) to determine I_{DS} and V_{DS}. 4%
(c) Calculate the transconductance g_m used in small-signal models. 2%

6、An op-amp circuit shown as follows (left circuit). The power supply used in op-amp IC is ±15 volt.
(a) Find V3, V4, and V5 for V1=V2=2 volt. 5%
(b) Find V3, V4, and V5 for V1=1.5 V, V2=1 V. 5%

7、Circuit shown as follows on the right hand side is a single-pole filter. Please determine the critical frequency and closed-loop voltage gain in the pass band. Where R=0.5 kΩ, R1=10 kΩ, R2=2 kΩ, and C=40 nF. 6%





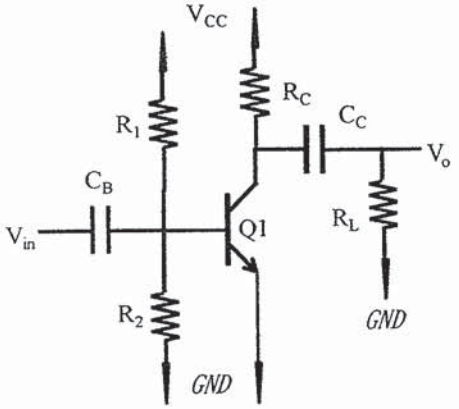
8、Sketch the CMOS inverter and explain briefly its operation. 10%

9、A BJT amplifier is shown as follows with β_f=120 and an on-voltage of **0.8 volt** for the E-B junction. V_{CC}=12 volt, R_1=800 kΩ, R_2=200 kΩ, R_C=5 kΩ, R_L=10 kΩ, C_B=0.2 μF and C_C=0.3 μF.

(a) Determine bias current I_C and V_{CE}. 5%

(b) Find the voltage gain in mid-frequency range. 5%

(c) Determine the total low-frequency response. 5%



10、For a full-wave bridge rectifier with idealized diodes, the input signal is v_s=5sin(2×10^{3}t) volt.

(a) Determine the frequency of the output signal.2%

(b) Calculate the equivalent direct voltage, V_{dc}, and V_{rms} value. 4%

$$V_T = \frac{kT}{q} \approx 25mV \qquad \varepsilon_{Si} \approx 10^{-12}\,F/cm \qquad \varepsilon_{ox} \approx 3.5\times10^{-13}\,F/cm$$

x	1	2	3	5	7
e^x	2.72	7.39	20.08	148.41	1096.6
ln(x)	0	0.693	1.099	1.609	1.946