**EE2255** **電子學 Midterm Exam_** **Spring 2021**
**04/27/2021**

**[Total 105pts]**
**If not otherwise specified, use the following parameters.**
$n_i = 1.5\text{x}10^{10}$ cm$^{-3}$; $V_T$=26mV; Diode: $V_{D.on}$=0.8V
npn: $V_{BE.on}$ = 0.8V; $\beta$=100; $V_{CE.sat}$=0.4V
pnp: $V_{EB,on}$ = 0.8V; $\beta$=25; $V_{EC,sat}$=0.4V

**單選題** [20pts]

( ) 1. Which is a possible donor for Silicon?
(a) Boron, B ; (b) Arsenic, As ; (c) Fluorine, F ; (d) Germanium, Ge

( ) 2. For a piece of intrinsic semiconductor at room temperature, which is **False**?
(a) free carriers are electrons and holes; (b) n=p; (c) Resistivity increase with temperature;
(d) Contains no impurities

( ) 3. At T=300K, a piece of Si is doped $N_A=10^{17}$cm$^{-3}$. What is the minority carrier and its concentration?
(a) electron, $10^{17}$ cm$^{-3}$; (b) hole, $10^{17}$ cm$^{-3}$ ; (c) electron, $2.25\text{x}10^3$ cm$^{-3}$; (d) hole, $2.25\text{x}10^3$ cm$^{-3}$

( ) 4. For a pn junction made with p-type Si substrate of $N_A=10^{15}$ cm$^{-3}$. N-region is made by counter doping with $N_D=1.01\text{x}10^{17}$ cm$^{-3}$. Electron and hole concentration in the n-region are?
(a) n=$1\text{x}10^{17}$ cm$^{-3}$, p=2250 cm$^{-3}$ ; (b) n=2250 cm$^{-3}$, p=$1\text{x}10^{17}$cm$^{-3}$ ; (c) n=$10^{15}$ cm$^{-3}$, p=$1.1\text{x}10^{17}$ cm$^{-3}$;
(d) n=p=$1.5\ \text{x}10^{10}$ cm$^{-3}$

( ) 5. Which is **True** in the depletion region of the pn junction with $N_D=10^{15}$ cm$^{-3}$ and $N_A=1\text{x}10^{17}$ cm$^{-3}$?
(a) $n=p=n_i$ ; (b) zero electric field ; (c) $x_n=100x_p$ ; (d) $x_n=0.01x_p$

( ) 6. For a junction capacitance under zero bias, $C_{j0}$ of 9fF, which answer is closest to the depletion capacitance at $V_D$=-6.4V?
(a)3fF ; (b) 6fF ; (c) 9fF ; (d) 18fF

( ) 7. For a npn BJT, with $V_{BE}$=0.8V, $V_{CE}$= 0.2V, this device is operating in
**(a)** Forward-active region; (b)Reverse-active region; (c) Saturation region; (d) Cutoff

( ) 8. For a pnp BJT operating in the forward-active region, which is **True**?
(a) Base current is determined by the electron diffusion current in emitter;
(b) Emitter current is solely hole current
(c) Collector current is limited by electron diffusion in base
(d) Collector/Base is forward-biased

( ) 9. For a npn BJT in the forward-active region with all other parameters and biasing voltages are fixed, while base width increases, then, which of the following is expected to increase?
(a) Current gain ; (b) Emitter current ; (c) Collector current ; (d) Output resistance

( ) 10. Which feature will **NOT** increase in an emitter degenerated circuit, against one without $R_E$ ?
(a)Output resistance
(b)Input resistance
(c)Bias stability
(d)Voltage Gain

**複選題** [15pts]

( ) 1. Which statements are **True** for an intrinsic Si at equilibrium state?
(a) $np=n_i^2$
(b) n=p
(c) When electric field is applied, drift current=0
(d) As temperature increases, conductivity decreases
(e) Has larger bandgap than Ge

( ) 2. A pn junction is under reverse bias with $V_R$ . As $V_R \uparrow$, which statements are correct?
(a) Potential barrier decreases
(b) Junction capacitance decreases
(c) Depletion width increases
(d) Free carrier densities in the depletion increase
(e) Peak electric field at the junction reduces

( ) 3. For a BJT in active region, which parameter will decrease with increasing $I_C$ ?
(a) $g_m$ ; (b) $r_\pi$ ; (c) $r_o$ ; (d) $V_A$ ; (e) effective base width

( ) 4. For a **npn** BJT in active region with all device parameters and bias voltages fixed, while base doping density, $N_B \downarrow$ :
(a)Current gain ↑
(b)Base current ↑
(c)Collector current ↑
(d)Output resistance↑
(e)Early voltage↑

( )5. Which are right descriptions for a common-emitter amplifier?
(a) Input resistance increase when $\beta$ of the transistor↑ ;
(b) Output resistance increase when $V_A$↑;
(c) Output signal is shifted by 90 degree phase from the input ;
(d) Maximum voltage gain is limited by $\beta$;
(e) Intrinsic gain is proportional to $I_C$;

**計算題** [70pts]

1. [15pts] There is a circuit as shown in Fig. 1. When $Vx$ =1V, the current $Ix$ is 0.2mA; when $Vx$ = 2V, $Ix$ is 0.5mA.
(a) Please calculate the values of resistance of $R_1$ and $Is$ of diode D1.
(b) Please use the large signal model to calculate the $Ix$ current, when we input the $Vx$ as 2.05V.
(c) Please use the small signal model to repeat (b) and compare the $Ix$ results of (b) and (c).

2.[15pts] Consider the Diode Filter Circuit in Fig. 2 with $V_{in}=5sin(2\pi t/T)$V, C=10μF, T=10msec. Assume that the capacitance has been charged, ignore the response of the first cycle.
(a) What is the peak output voltage?
(b) What is the minimum output voltage after the second cycle?
(c) Find the percentage of diode conduction period/T after the second cycle.

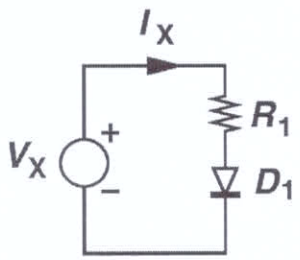


Figure 1

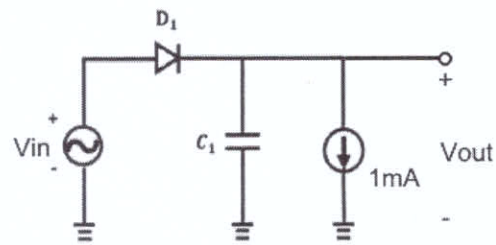


Figure 2

3.[10pts] For the circuit in Figure 3, with $R_1=5k\Omega$, $I_{S1}=1x10^{-17}A$, $Is_2=2x10^{-17}A$.
(a) For $I_X=1mA$, $V_B$=?
(b) What is the small-signal transconductance of $Q_2$?.

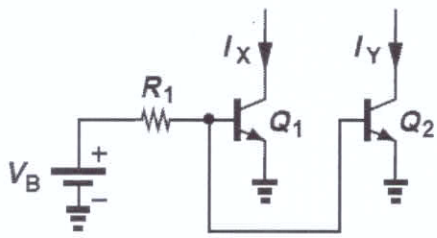


Figure 3

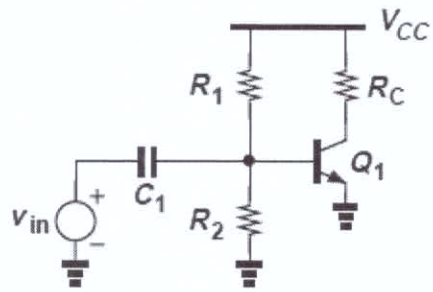


Figure 4

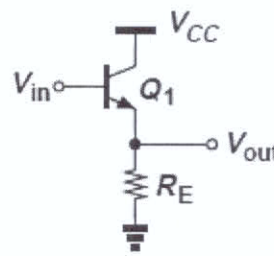


Figure 5

4.[15pts] For the circuit in Figure 4, with $V_{CC}$=2.5V; $R_1=17k\Omega$, $R_2=8k\Omega$, $R_C=2k\Omega$ and $I_{S1}=2x10^{-17}A$.
Assume $C_1$ is open for DC analysis, short for AC analysis.
(a) What is the collector current of $Q_1$ (ignore base current for this part)?
(b) If $V_{out}$ is at the collector of $Q_1$, find the small-signal voltage gain.
(c) What is the input resistance of this stage?

5. [15pts] For the circuit in Figure 5, with $V_{CC}$=2.5V; $R_E=100\Omega$, $Q_1$: $V_{BE.on}=0.8V$.
Let the DC input level, $V_{IN}=1V$.
(a) What is the emitter current of $Q_1$?
(b) Find the small-signal voltage gain.
(c) What is the output resistance of this stage?