九十七學年四技二專第五次聯合模擬考試
電機與電子群　專業科目（一）　詳解

97-5-03-4
97-5-04-4

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
D	B	D	A	B	D	B	A	A	C	B	D	C	C	B	A	D	D	D	D	B	D	D	C	D
26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
B	D	C	B	D	C	B	B	C	B	B	C	C	C	C	B	B	B	A	D	B	D	B	B	C

第一部份：基本電學

1. (1) $P_o = 2\text{ hp} = 2\times 746 = 1492\text{ W}$

(2) $P_i = \dfrac{P_o}{\eta} = \dfrac{1492}{0.85} \cong 1755\text{ W}$

(3) $I = \dfrac{P_i}{V} = \dfrac{1755}{110} \cong 16\text{ A}$

2. (1) $R_2 = \rho\dfrac{\ell_2}{A_2} = \rho\dfrac{a}{2b^2} = 10\text{ k}\Omega$

(2) $R_1 = \rho\dfrac{\ell_1}{A_1} = \rho\dfrac{2a}{2b^2} = 20\text{ k}\Omega$

(3) $I = \dfrac{12}{R_1 + R_2} = \dfrac{12}{10\text{ k} + 20\text{ k}} = 0.4\text{ mA}$

3. (1) $V_2 = E - V_1 = 15 - 10 = 5\text{ V}$

(2) $I = \dfrac{V_2}{R_2} = \dfrac{5}{50} = 0.1\text{ A}$

(3) $P_1 = V_1 I = 10\times 0.1 = 1\text{ W}$

4. (1) $E = V_1 = V_2 = 12\text{ V}$

(2) $I_1R_1 = I_2R_2 = E = 12\text{ V}$，因 $R_1 = 2R_2$
則 $I_2 = 2I_1 = 4\text{ mA}$，故 $I_1 = 2\text{ mA}$

(3) $R_2 = \dfrac{V_2}{I_2} = \dfrac{12}{4\text{ mA}} = 3\text{ k}\Omega$

5. (1) 因 $I_1 = 0$，故電橋平衡，$R = 2\times\dfrac{8}{4} = 4\,\Omega$

(2) $R_{ab} = (8+4)//(R+2) = 12//6 = 4\,\Omega$

(3) $I = \dfrac{6}{8+4} + \dfrac{6}{R+2} = 0.5 + 1 = 1.5\text{ A}$

6. (1) $V_{3\Omega} = \dfrac{\frac{12}{6} + \frac{0}{3} + 1}{\frac{1}{6} + \frac{1}{3} + 0} = 6\text{ V}$

(2) $V_1 = V_{3\Omega} + 1\times 4 = 6 + 4 = 10\text{ V}$

7. (1) $V_{BD} = \dfrac{\frac{14}{2} + \frac{0}{3} + \frac{-6}{6}}{\frac{1}{2} + \frac{1}{3} + \frac{1}{6}} = 6\text{ V}$

(2) $I_{AB} = \dfrac{14-6}{2} = 4\text{ A}$

(3) $I_{AC} = \dfrac{14-(-6)}{5} = 4\text{ A}$

(4) $I_1 = I_{AB} + I_{AC} = 4 + 4 = 8\text{ A}$

(5) $I_{BD} = \dfrac{V_{BD}}{3} = \dfrac{6}{3} = 2\text{ A}$

(6) $I_2 = I_1 - I_{BD} = 8 - 2 = 6\text{ A}$

(7) $I_3 = I_1 - I_{AB} = 8 - 4 = 4\text{ A}$

(8) $V_{AB} = I_{AB}\times 2 = 4\times 2 = 8\text{ V}$

(9) $V_{AC} = 14 - (-6) = 20\text{ V}$

8. (1) 求 R_N：將 $6\,\Omega$ 開路，12 V 電壓源短路，1 A 電流源開路，$R_N = 12\,\Omega$

(2) 求 V_N：將 $6\,\Omega$ 短路，使用重疊定理，得 $I_N = \dfrac{12}{12} + 1 = 2\text{ A}$

(3) $I = I_N\dfrac{R_N}{R_N + 6} = 2\times\dfrac{12}{12+6} = \dfrac{4}{3}\text{ A}$

(4) $V_{AB} = 6I = 6\times\dfrac{4}{3} = 8\text{ V}$

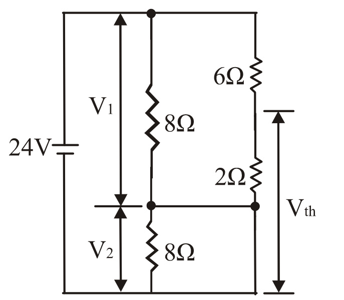
9. (1) $R_L = R_{th} = (8//8+2)//6 = 3\,\Omega$

(2) $V_1 = 24\times\dfrac{8//(6+2)}{8 + 8//(6+2)} = 8\text{ V}$

(3) $V_2 = 24 - V_1 = 24 - 8 = 16\text{ V}$

(4) $V_{th} = V_2 + V_1\times\dfrac{2}{2+6}$
$= 16 + 8\times\dfrac{2}{8} = 18\text{ V}$

(5) $P_{max} = (\dfrac{V_{th}}{R_{th} + R_L})^2 R_L$
$= (\dfrac{18}{3+3})^2\times 3 = 27\text{ W}$



10. $C = \varepsilon_r\varepsilon_o\dfrac{A}{d} = 3\times 8.85\times 10^{-12}\times\dfrac{1\text{ m}^2}{1\times 10^{-3}\text{ m}} = 26.55\text{ nF}$

11. (1) $C_T = 12//(12+12) = 8\ \mu\text{F}$

(2) $V_{AB} = 20\times\dfrac{24}{24+12} = \dfrac{40}{3}\text{V}$

(3) $Q_T = Q_1 = C_T E = 8\mu\times 20 = 160\ \mu\text{C}$

(4) $Q_2 = Q_3 = \frac{Q_T}{2} = 80\ \mu C$

12. (1) $L_1 + L_2 + 2M = 120$

(2) $L_1 + L_2 - 2M = 80$

(3) 將(1)式－(2)式，得 $40\ mH = 4\ M$ ，$M = 10\ mH$

(4) 將(1)式＋(2)式，得 $2(L_1 + L_2) = 200$ ，$L_1 + L_2 = 100\ mH$

(5) 因 $L_1 = 4L_2$ ，則 $L_1 + L_2 = 4L_2 + L_2 = 100$ ，故 $L_2 = 20\ mH$ ，$L_1 = 80\ mH$

(6) $k = \frac{M}{\sqrt{L_1 L_2}} = \frac{10}{\sqrt{80 \times 20}} = \frac{10}{40} = 0.25$

13. (1) $F = B\ell I \sin\theta$，當 $\theta = 90°$ 時，導線受力最大，即 $F = 0.1 \times 1 \times 5 = 0.5$ 牛頓

14. (1) 開關 S 接通(ON)瞬間，電容器視爲短路

$i = \frac{16}{4\ k + 12\ k//6\ k} = 2\ mA$

$i_C = i \times \frac{12\ k}{12\ k + 6\ k} = 2\ mA \times \frac{2}{3} = \frac{4}{3}\ mA$

(2) 電路穩定時，電容器視爲開路

$i = \frac{16}{4\ k + 12\ k} = 1\ mA$ ，$i_C = 0$

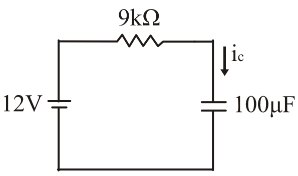
$V_C = 16 \times \frac{12\ k}{4\ k + 16\ k} = 12\ V$

(3) $\tau = RC = (4\ k//12\ k + 6\ k)100\ \mu F$

$= 0.9\ sec$

經過一個時間常數後

$V_C = 12 \times 0.632 = 7.584\ V$



15. (1) $\tau = \frac{L}{R} = \frac{10\ m}{2} = 5\ mS$

(2) $i = \frac{E}{R}(1 - e^{-\frac{t}{\tau}}) = \frac{20}{2}(1 - e^{-\frac{t}{5m}}) = 8.65\ A$

故 $t = 10\ mS$

16. (1) 平均值 $V_{dc} = 8\ V$

(2) 有效値 $V_{rms} = \sqrt{8^2 + (\frac{6\sqrt{2}}{\sqrt{2}})^2} = 10\ V$

17. (1) $X_C = \frac{1}{\omega C} = \frac{1}{10^3 \times 0.1\ \mu} = 10\ k\Omega$

(2) $\overline{Z} = R - jX_C = 10\ k - j10\ k = 10\sqrt{2}\angle -45°$

(3) $\overline{V} = 100\angle 0°$

(4) $\overline{I} = \frac{\overline{V}}{\overline{Z}} = \frac{100\angle 0°}{10\sqrt{2}\angle -45°} = \frac{10}{\sqrt{2}}\angle 45°$

則 $i(t) = 10\sin(10^3 t + 45°)$ 毫安

18. (1) $B_L = \frac{1}{\omega L} = \frac{1}{10^3 \times 10\ m} = 0.1$ 姆歐

(2) $Y = G - jB_L = 0.1 - j0.1 = 0.1\sqrt{2}\angle -45°$ 姆歐

(3) $Z = \frac{1}{Y} = \frac{1}{0.1\sqrt{2}} = 5\sqrt{2}$ 歐姆

(4) $V = \frac{20}{\sqrt{2}}\angle 0°$ 伏特

(5) $I_R = VG = \frac{20}{\sqrt{2}} \times 0.1 = \sqrt{2}$ 安培

(6) $I_L = VB_L = \frac{20}{\sqrt{2}} \times 0.1 = \sqrt{2}$ 安培

(7) $I = VY = \frac{20}{\sqrt{2}}\angle 0° \times 0.1\sqrt{2}\angle -45° = 2\angle -45°$ 安培

(8) $i(t) = 2\sqrt{2}\sin(10^3 - 45°)$ 安培

19. (1) $I_1 = \frac{120}{30} - \frac{120}{12} = -6\ A$

(2) $I = \sqrt{(\frac{120}{15})^2 + (-6)^2} = 10\ A$

(3) $Z = \frac{E}{I} = \frac{120}{10} = 12\ \Omega$

(4) 功率因數 $PF = \frac{G}{Y} = \frac{Z}{R} = \frac{12}{15} = 0.8$

20. (1) $V = \frac{100}{\sqrt{2}}\angle 60°\ V$ ，$I = \frac{20}{\sqrt{2}}\angle 30°\ A$

(2) $S = VI^* = \frac{100}{\sqrt{2}}\angle 60° \frac{20}{\sqrt{2}}\angle -30° = 1000\angle 30°$

$= 500\sqrt{3} + j500\ VA$

(3) $P = 500\sqrt{3}\ W$ ，$Q = 500\ VAR$

(4) $Z = \frac{V}{I} = 5\angle 30°\ \Omega$

(5) 電壓 $v(t)$ 相位超前電流 $i(t)$ 相位 $30°$，負載爲電感性

21. (1) 並聯消耗功率 $P_P = \frac{E^2}{R}$

(2) 串聯消耗功率 $P_S = I^2 R = (\frac{E}{\sqrt{R^2 + X^2}})^2 R$

$= \frac{E^2}{R}(\frac{R}{\sqrt{R^2 + X^2}})^2 = P_P \cos^2\theta_S$

(3) $P_P = \frac{P_S}{\cos^2\theta_S} = \frac{320}{0.8^2} = 500\ W$

22. (1) $f_o = f\sqrt{\frac{X_C}{X_L}} = 1k\sqrt{\frac{500}{20}} = 5\ kHz$

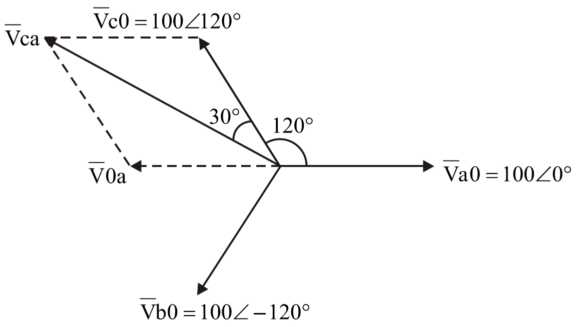
(2) $P = \frac{(\frac{100}{\sqrt{2}})^2}{10} = 500\ W$

23. (1) 電容電壓相位滯後電路電流相位 $90°$

(2) 電感電壓相位超前電路電流相位 $90°$

24. $I_L = \frac{P_o}{\sqrt{3}V_L\cos\theta} = \frac{5 \times 746}{\sqrt{3} \times 220 \times 0.8} = 12.2\ A$

25.



第二部份：電子學

26. (1) 最大值 $V_m = 100\ V$

(2) $t = \frac{1}{180}$ 秒時的瞬間值

$v(t) = 100\sin(2\pi \times 60 \times \frac{1}{180} + 60°) = 100\sin(180°) = 0$

(3) $f = \frac{\omega}{2\pi} = \frac{377}{2\pi} = 60\ Hz$

(4) 電壓信號 $v(t) = 100\sin(377t + 60°)$ 與電流信號

$i(t) = 10\cos(377t - 30°) = 10\sin(377t + 60°)$

相位差 $\theta = 60° - 60° = 0°$

27. (A) 電洞濃度 $p \cong N_A = \frac{5\times 10^{22}}{10^8} = 5\times 10^{14}\ /cm^3$

(B) 電子濃度

$n = \frac{n_i^2}{N_A} = \frac{(1.5\times 10^{10})^2}{5\times 10^{14}} = 4.5\times 10^5\ /cm^3$

(C) 本質半導體、P 型半導體及 N 型半導體中的電子數目等於質子數目，電性爲中性

(D) 多數載子爲電洞，少數載子爲電子

28. (1) $I_S = \frac{E - V_Z}{R_S} = \frac{12-6}{1\ k} = 6\ mA$

(2) $I_{L(max)} = I_S - I_{ZK} = 6 - 1 = 5\ mA$

(3) $R_{L(min)} = \frac{V_Z}{I_{L(max)}} = \frac{6}{5\ m} = 1.2\ k\Omega$

29. (1) 次級 $V_m = 40\times\frac{1}{2}\times\frac{1}{2} = 10\ V$

(2) $V_{dc} = 0.636\ V_m = 0.636\times 10 = 6.36\ V$

(3) PIV= $2\ V_m = 2\times 10 = 20\ V$

30. (1) $V_{r(rms)} = \frac{4.8}{R_L C} V_{dc} = \frac{4.8}{10\times 100}\times 10 = 48\ mV$

(2) $V_{r(P-P)} = 2\sqrt{3}\ V_{r(rms)}$

$= 2\times 1.732\times 48\ mV = 166\ mV$

31. (1) 當 $V_i \le -2\ V$ 時，二極體導通，$V_o = -2\ V$

(2) 當 $V_i > -2\ V$ 時，二極體截止，$V_o = V_i$

32. (1) 射極摻雜濃度最高，但逆向耐壓最低

(2) 集極摻雜濃度最低，但逆向耐壓最高

33. NPN 電晶體操作在主動區時，$V_{BE} > 0$，$V_{BC} < 0$

$V_{CE} > 0$，則 $V_C > V_B > V_E$

34. (1) $I_{C(sat)} = \frac{V_{CC} - V_{CE(sat)}}{R_C} = \frac{5-0.2}{R_C} = \frac{4.8}{R_C}$

(2) $I_B = \frac{V_{BB} - V_{BE}}{R_B} = \frac{2.7-0.7}{R_B} = \frac{2}{R_B}$

(3) 飽和條件：$\beta I_B \ge I_{C(sat)}$，則 $100\times\frac{2}{R_B} \ge \frac{4.8}{R_C}$

故 $R_B \le 41.6\ R_C$

35. (1) 減少 I_C 值，可以使工作點由飽和區附近移向直流負載線中央，因 $I_B = \frac{V_{CC} - V_{BE}}{R_B}$，$I_C = \beta I_B$，故增加 R_B 值即可減少 I_C

36. (1) $I_B = \frac{0-0.7-(-12)}{565\ k} = 0.02\ mA$

(2) $I_C = \beta I_B = 100\times 0.02\ m = 2\ mA$

(3) $0 - V_{EC} - (-12) = I_C R_C$

則 $V_{EC} = 12 - I_C R_C = 12 - 2\ m\times 2\ k = 8\ V$

故 $V_{CE} = -V_{EC} = -8\ V$

(4) $V_B = V_{BE} = -V_{EB} = -0.7\ V$

(5) $I_{C(sat)} = \frac{12-0.2}{2\ k} = 5.9\ mA$，因 $\beta I_B > I_{C(sat)}$

故 BJT 工作於主動區

37. (1) $I_{C(sat)} \cong \frac{V_{CC}}{R_C + R_E} = \frac{12}{5\ k + 1\ k} = 2\ mA$

(2) $I_B = \frac{V_{CC} - V_{BE}}{R_B + (1+\beta)R_E} = \frac{12-0.7}{200\ k + 101\ k} = 37.5\ \mu A$

因 $\beta I_B > I_{C(sat)}$，電晶體已飽和，故需重新計算 I_B 值

(3) $V_{CC} = V_{BE} + I_B R_B + I_E R_E$

$= V_{BE} + I_B R_B + (I_B + I_{C(sat)} R_E)$

則 $I_B = \frac{V_{CC} - V_{BE} - I_{C(sat)} R_E}{R_B + R_E}$

$= \frac{12 - 0.7 - 2\ m\times 1\ k}{200\ k + 1\ k} = 46.3\ \mu A$

38. (1) $\frac{V_o}{V_s} = \frac{V_i}{V_s}\frac{V_o}{V_i} = -\beta\frac{r_\pi}{R_s + r_\pi}\frac{R_C // R_L}{r_\pi}$

$= -100\times\frac{2\ k}{0.5\ k + 2\ k}\frac{4\ k//12\ k}{2\ k} = -120$

39. (1) $I_E \cong \frac{V_{CC} - V_{CE}}{R_C + R_E} = \frac{12-6}{4.7\ k + 1.3\ k} = 1\ mA$

(2) $V_T = \frac{(273.2+27)}{11600} = 25.8\ mV$

(3) $r_e = \frac{V_T}{I_E} = \frac{25.8}{1} \cong 26\ \Omega$

(4) $\frac{V_o}{V_i} = -\frac{R_C}{r_e} = -\frac{4.7\ k}{26} = -180$

40. (1) $I_2 = \frac{V_B}{R_{B2}} = \frac{V_{BE} + V_E}{R_{B2}} = \frac{0.7+1.3}{5\ k} = 0.4\ mA$

(2) $I_1 = I_2 + I_B \cong I_2 = \dfrac{V_{CC} - V_B}{R_{B1}}$

故 $R_{B1} = \dfrac{V_{CC} - V_B}{I_1} = \dfrac{24-2}{0.4\text{ m}} = 55\text{ k}\Omega$

(3) 因 R_{B2} 開路

故 $I_B = \dfrac{V_{CC} - V_{BE}}{R_{B1} + (1+\beta)R_E} = \dfrac{24-0.7}{55\text{ k} + 201\times 1.3\text{ k}}$

$= 73.6\ \mu\text{A}$

(4) $I_{C(sat)} = \dfrac{V_{CC} - V_{CE(sat)}}{R_C + R_E} = \dfrac{24-0.2}{4.7\text{ k} + 1.3\text{ k}} = 4\text{ mA}$

(5) 因 $\beta I_B > I_{C(sat)}$，故電晶體工作於飽和區

41. (1) $A_{i(dB)} = 20\log A_i = 20\log 10 = 20\text{ dB}$

(2) $A_{p(dB)} = \dfrac{1}{2}(A_{v(dB)} + A_{i(dB)}) = 40$

故 $A_{v(dB)} = 80 - A_{i(dB)} = 80 - 20 = 60\text{ dB}$

(3) $A_{v(dB)} = 20\log A_v = 60$，故 $A_v = 1000$

(4) $A_v = A_{v1}A_{v2}$，故 $A_{v2} = \dfrac{A_v}{A_{v1}} = \dfrac{1000}{-100} = -10$

42. (1) $I_D = I_{DSS}(1 - \dfrac{V_{GS}}{V_{GS(off)}})^2 = 16\times(1 - \dfrac{V_{GS}}{-4})^2$

(2) $V_{GS} = V_G - V_S = -I_D R_S = -I_D(0.5)$

解(1)(2)聯立方程式，得 $V_{GS} = -2\text{ V}$，$I_D = 4\text{ mA}$

(3) JFET 工作於定電流區的條件：

$V_{DG} \ge |V_{GS(off)}| = 4$

則 $V_{DG} = V_D - V_G = V_{DD} - I_D R_D - 0 \ge 4$

故 $R_D \le \dfrac{V_{DD} - 4}{I_D} = \dfrac{12-4}{4\text{ m}} = 2\text{ k}\Omega$

43. (1) 對空乏型 FET 元件而言，$V_{GS} = 0$ 時，

$I_D = I_{DSS}(1 - \dfrac{V_{GS}}{V_{GS(off)}})^2$，因 V_{GS} 可正、可負，故 I_D 的最大值將會大於 I_{DSS}

44. (1) $I_D = I_{DSS}(1 - \dfrac{V_{GS}}{V_{GS(off)}})^2 = 8\times(1 - \dfrac{V_{GS}}{-4})^2$

(2) $V_{GS} = V_G - V_S = -I_D R_S = -I_D(0.5 + 0.5)$

解(1)(2)聯立方程式，得 $V_{GS} = -2\text{ V}$，$I_D = 2\text{ mA}$

(3) $R_D = \dfrac{V_{DD} - V_{DS} - I_D R_S}{I_D}$

$= \dfrac{24 - 12 - 2\text{ m}\times 1\text{ k}}{2\text{ m}} = 5\text{ k}\Omega$

(4) $g_m = \dfrac{2I_{DSS}}{|V_{GS(off)}|}(1 - \dfrac{V_{GS}}{V_{GS(off)}})$

$= \dfrac{2\times 8}{4}(1 - \dfrac{-2}{-4}) = 2\text{ mA/V}$

(5) $\dfrac{V_o}{V_i} = -\dfrac{R_D}{\dfrac{1}{g_m} + R_{S1}} = -\dfrac{5\text{ k}}{\dfrac{1}{2\text{ m}} + 500} = -5$

45. (1) $\dfrac{V_o}{V_i} = -\dfrac{100}{10} = -10$

(2) $V_o = -10V_i = 10\times 2 = -20\text{ V}$，因 V_o 已超過電源電壓，輸出已飽和，$V_o = -12\text{ V}$

46. (1) $\dfrac{V_o}{V_i} = -\dfrac{100}{20}\times(1 + \dfrac{R}{50}) = -\dfrac{12}{1} = -12$

故 $R = 70\text{ k}\Omega$

47. (1) $\dfrac{\sin\theta}{\sin 90^\circ} = \dfrac{1}{2}$，則 $\theta = 30^\circ$

(2) 工作週期

$= \dfrac{180^\circ + 2\theta}{360^\circ}\times 100\% = \dfrac{180^\circ + 60^\circ}{360^\circ}\times 100\% = 66\%$

48. (1) 通帶電壓增益 $A_V = 1 + \dfrac{R_2}{R_1} = 1 + \dfrac{90\text{ k}}{10\text{ k}}$

則 $A_{V(dB)} = 20\log 10 = 20\text{ dB}$

(2) $f_L = \dfrac{1}{2\pi RC} = \dfrac{1}{2\pi\times 10\text{ k}\times 0.1\mu} = 159\text{ Hz}$，截止點增益爲 $20\text{ dB} - 3\text{ dB} = 17\text{ dB}$

(3) 截止帶電壓增益 $A_V = \dfrac{V_o}{V_i} \cong \dfrac{f}{f_L}(1 + \dfrac{R_2}{R_1})$

$20\log A_V = 20\log(\dfrac{f}{f_L}) + 20\log(1 + \dfrac{R_2}{R_1})$

$= 20\log(\dfrac{f}{159}) + 20\text{ dB}$

(4) 當 $f = 15.9\text{ Hz}$ 時，

$20\log(\dfrac{f}{159}) + 20\text{ dB} = 20\log(\dfrac{15.9}{159}) + 20$

$= -20 + 20 = 0\text{ dB}$

(5) 當 $f = 1.59\text{ kHz}$ 時，增益爲 20 dB

50. $T = 2RC\ln(1 + \dfrac{2R_1}{R_2})$