103 學年度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

103-5-03-4、103-5-04-4

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
A	C	D	B	A	D	B	C	B	B	B	A	C	B	D	C	C	D	A	B	B	C	C	C	A
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
A	C	A	B	C	B	B	C	A	B	D	D	A	D	D	B	B	B	D	C	A	C	A	D	C

第一部分：基本電學

1. $V_C = V_C'$，$i \cdot X_C = 5i \cdot X_C'$，$X_C' = \frac{1}{5}X_C$

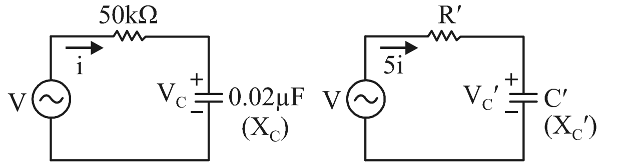
$\Rightarrow C' = 5C = 5 \times 0.02\ \mu = 0.1\ \mu F$

$\frac{V}{Z} = i$，$\frac{V}{Z'} = 5i$，$\frac{Z}{Z'} = 5 \Rightarrow Z' = \frac{Z}{5}$

$\sqrt{R'^2 + (\frac{1}{5}X_C)^2} = \frac{\sqrt{(50\ k)^2 + X_C^2}}{5}$

$(R')^2 + \frac{X_C^2}{25} = \frac{(50\ k)^2}{25} + \frac{X_C^2}{25}$

$\Rightarrow (R')^2 = \frac{(50\ k)^2}{25} = 100\ M \Rightarrow R' = 10\ k\Omega$



2. $W = \frac{1}{2}LI^2 = \frac{1}{2} \times \frac{NBA}{I} \times I^2$ ($LI = N\phi \Rightarrow L = \frac{N\phi}{I} = \frac{NBA}{I}$)

$= \frac{1}{2}NIBA = \frac{1}{2}FBA = \frac{1}{2}H \cdot \ell \cdot B \cdot A$

$= \frac{1}{2}\frac{B}{\mu} \times B \times A \times \ell$ ($A \times \ell$ = 體積)

$= \frac{1}{2} \times \frac{B^2}{\mu} \times A \times \ell = \frac{1}{2} \times \frac{1.2^2}{4\pi \times 10^{-7}} \times 150 \times 10^{-6} = \frac{270}{\pi}$ 焦耳

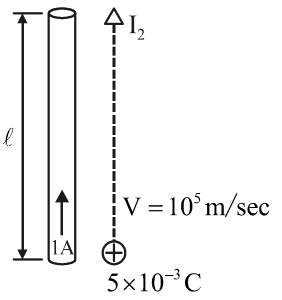
3. $I_2 = \frac{Q}{t} = \frac{Q}{\frac{\ell}{V}} = \frac{Q \times V}{\ell}$

(V：速度，ℓ：距離)

$F = \frac{\mu I_1 I_2 \times \ell}{2\pi d} = \frac{\mu I_1 \times \frac{QV}{\ell} \times \ell}{2\pi d}$

$= \frac{\mu I_1 QV}{2\pi d}$

$= \frac{4\pi \times 10^{-7} \times 1 \times 5 \times 10^{-3} \times 10^5}{2\pi \times 0.1} = 10^{-3}$ 牛頓



4. 逆電場方向意指電子由低電位移至高電位，故消耗能量且電位上升

5. 電源切斷表示電容器中的電荷量 Q 已固定

則 $Q = Q' \Rightarrow CV = C'V'$，又電容的距離減半

故 $C' = 2C (C = \varepsilon\frac{A}{d})$，因此 $CV = 2C \times V' \Rightarrow V' = \frac{1}{2}V$

$W = \frac{1}{2}QV = 8$，$W' = \frac{1}{2}Q'V' = \frac{1}{2} \times Q \times \frac{1}{2}V = \frac{1}{4}QV$

$W' = \frac{1}{2}W = \frac{1}{2} \times 8 = 4$ 焦耳

6. $\begin{cases} X_L - X_C = 0 \\ 2X_L - \frac{1}{2}X_C = 45 \end{cases}$

$\frac{3}{2}X_C = 45 \Rightarrow X_C = X_L = 30\ \Omega$ (諧振時)

品質因素 $Q_S = \frac{X_L}{R} = \frac{X_C}{R} = \frac{30}{50} = 0.6$

$X_L = \omega L \Rightarrow 100L = 30 \Rightarrow L = 0.3\ H$

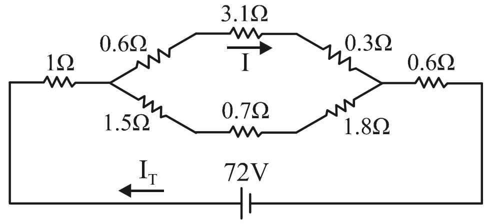
$X_C = \frac{1}{\omega C} = \frac{1}{100C} = 30 \Rightarrow C = \frac{1}{3}\ mF$

7. 依據惠斯登電橋實驗結果之推導，$R_X \times$ 負載 $= 4 \times 8$，$16 \times$ 負載 $= 32$，故負載電阻值為 2 Ω

8. $\alpha_{20} = \frac{1}{222} \Rightarrow \alpha_{20} = \frac{1}{T_0 + 20} \Rightarrow T_0 = 202$

$\frac{T_0 + t_2}{T_0 + t_1} = \frac{R_2}{R_1} \Rightarrow \frac{202 + t_2}{202 + 28} = \frac{150}{10} \Rightarrow t_2 = 3248°C$

9. 將圖中部分電路 $\Delta \to Y$，如下圖所示



$I_T = \frac{72}{1 + (4 // 4) + 0.6} = 20\ A$，$I = 20 \times \frac{4}{4+4} = 10\ A$

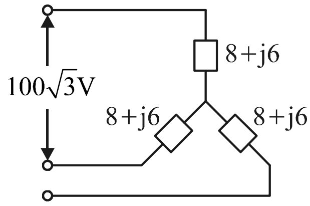
10. 電容穩態 ⇒ 開路，電感穩態 ⇒ 短路

$V_C = 4\ \Omega$ 上的壓降 $= 60 \times \frac{4}{4+8} = 20\ V$

11. $V_\ell = 100\sqrt{3}$，$V_P = \frac{100\sqrt{3}}{\sqrt{3}} = 100\ V$ (相電壓)

$I_P = \frac{100}{8 + j6} = 10\ A$，$P_\phi = 10^2 \times 8 = 800\ W$

$P_{3\phi} = 3 \times 800 = 2400\ W$



12. 體積不變，拉長 m 倍，面積變爲 $\frac{1}{m}$ 倍

$R=\rho\frac{\ell}{A}\Rightarrow R\propto\frac{\ell}{A}$ ，$R'=10\times\frac{4}{(\frac{1}{2})^2}=160\ \Omega$

(線徑 $\frac{1}{n}$ 倍，面積 $\frac{1}{n^2}$ 倍，長度 n^2 倍)

13. 此兩電路分別爲電感串聯互助及電感並聯互助

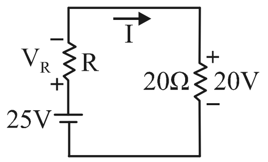
則 $L_S=L_1+L_2+2M=4+8+2\times1=14\ H$

$L_P=\frac{L_1\times L_2-M^2}{L_1+L_2-2M}=\frac{4\times8-2^2}{4+8-2\times2}=3.5\ H$

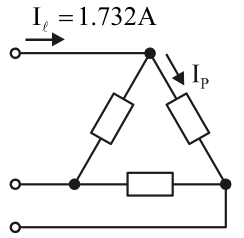
$\frac{L_S}{L_P}=\frac{14}{3.5}=4$

14. 開路電壓則爲 $E=25\ V$ ，$I=\frac{20}{20}=1\ A$

電阻上的電壓 $V_R=25-20=5\ V$ ，$R=\frac{V}{I}=\frac{5}{1}=5\ \Omega$



15. I_P(相電流)$=\frac{1.732}{\sqrt{3}}\fallingdotseq1\ A$



16. $Q=\frac{60\ k}{0.6}\sqrt{(1^2-0.6^2)}=80\ k$

$Q'=\frac{60\ k}{0.8}\sqrt{1^2-0.8^2}=45\ k$

$Q_C=Q-Q'=80\ k-45\ k=35\ kVAR$

17. $W_C=\frac{1}{2}QV=\frac{1}{2}CV^2=\frac{1}{2}\times50\ \mu\times50^2=62.5\ mJ$

18. $\vec{E}_1=9\times10^9\times\frac{2\times10^{-8}}{1^2}=180$ NT/C (向右)

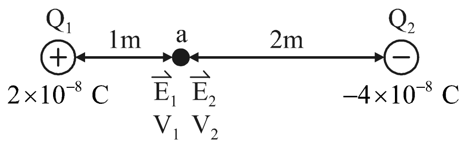
$\vec{E}_2=9\times10^9\times\frac{4\times10^{-8}}{2^2}=90$ NT/C (向右)

$\vec{E}=\vec{E}_1+\vec{E}_2=180+90=270$ NT/C (向右)

$V_1=9\times10^9\times\frac{2\times10^{-8}}{1}=180\ V$

$V_2=9\times10^9\times\frac{-4\times10^{-8}}{2}=-180\ V$

$V=V_1+V_2=180+(-180)=0\ V$



19. $F=NI=H\ell$

$32\times6=H\times1.6\Rightarrow H=120\ AT/m$

20. 充電時間常數 $\tau=R\times C=(2\ k\ //\ 2k)\times5\ m=5$ 秒

V_C 充電暫態方程式 $V_C(t)=10(1-e^{\frac{-t}{5}})$

$t=10$ 代入 $\Rightarrow V_C(10)=10(1-e^{-2})\fallingdotseq10(1-0.135)$

$=10\times0.865=8.65\ V$

21. $f_0=\frac{1}{2\pi\sqrt{LC}}=\frac{1}{2\pi\sqrt{5\ \mu\times0.5\ m}}=\frac{1}{2\pi\sqrt{2.5\times10^{-9}}}$

$\fallingdotseq3183\ Hz$

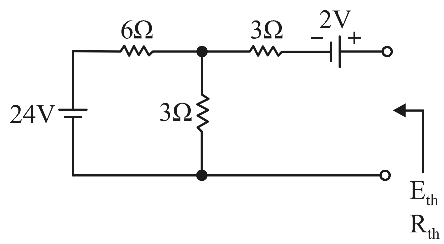
22. 求 R_{AB} 時，R_{CD} 間電阻可拔除視爲開路

則 $R_{AB}=2R\ //\ 2R\ //\ R=0.5R$

又 $R_{AB}=R_{AC}=R_{CD}=R_{BD}=0.5R$

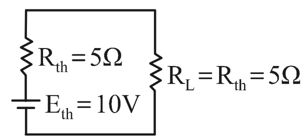
因此 $2R_X=0.5R\Rightarrow R_X=\frac{1}{4}R=\frac{1}{4}\times12=3\ \Omega$

23. 將電路化爲戴維寧等效電路



$\begin{cases}R_{th}=(6\ //\ 3)+3=5\ \Omega\\ E_{th}=24\times\frac{3}{6+3}+2=10\ V\end{cases}$

$P_{max}=\frac{5^2}{5}=5\ W$



24. 利用節點電壓法

$\frac{V_A-6}{3}+\frac{V_A}{6}+\frac{V_A-12}{2}=0$

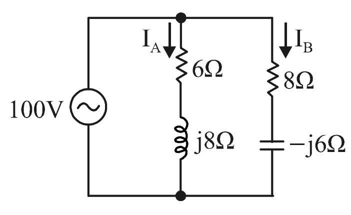
$\Rightarrow2V_A-12+V_A+3V_A-36=0$

$6V_A=48\Rightarrow V_A=8\ V$

25. $I_A=\frac{100}{\sqrt{6^2+8^2}}=10\ A$ ，$I_B=\frac{100}{\sqrt{8^2+6^2}}=10\ A$

$P=10^2\times6+10^2\times8=1400=1.4\ kW$

$Q=10^2\times8-10^2\times6=200=0.2\ kVar$



第二部分：電子學

26. (A) 方波之 $V_{rms} = V_{av}$，正弦波之 $V_{rms} = 1.11\ V_{av}$，三角波之 $V_{rms} = 1.155\ V_{av}$，故有效值由小到大依序爲方波、正弦波、三角波

(B) 平均値與最大值之比率

$$V_{av} = \frac{V_m \times T_1 + 0 \times T_2}{T} = \frac{T_1}{T} \times V_m$$

$$\Rightarrow \text{Duty cycle} = \frac{T_1}{T} = \frac{V_{av}}{V_m}$$

(C) 鋸齒波 $C.F. = \sqrt{3} = 1.732$

(D) 半波整流電路 $F.F. = \frac{V_{o(rms)}}{V_{o(av)}} = \frac{\frac{V_m}{2}}{\frac{V_m}{\pi}} = 1.57$

27. $I_{S2} = I_{S1} \times 2^{\frac{T_2 - T_1}{10}} \Rightarrow I_S$ 會隨溫度升高而增加

28. (1) 純矽半導體加入三價鎵原子，每加入一個原子，就會多一帶正電的電洞而形成 P 型半導體

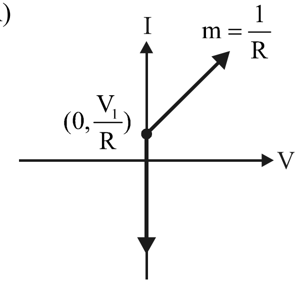
(2) 依摻雜比例可算出電洞濃度

$$P_P = \frac{5 \times 10^{22}}{2 \times 10^8} = 2.5 \times 10^{14}\ (\text{電洞}/cm^3)$$

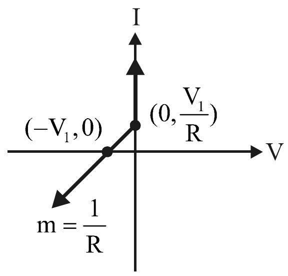
依質量作用定律 $N_i^2 = p \times n$

$$\text{電子濃度 } n = \frac{N_i^2}{p} = \frac{(1.5 \times 10^{10})^2}{2.5 \times 10^{14}} = 9 \times 10^5\ (\text{電子}/cm^3)$$

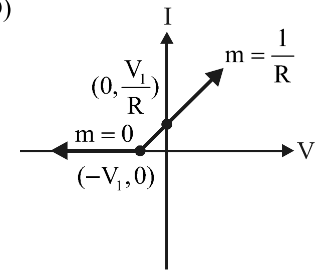
29. (A)



(C)



(D)



31. $r\% = \frac{2.4}{R_L \times C} \times 100\% = 5.45\%$

32. CB 間順向導通，$V_B = (4 - 0.7)\frac{200\ k}{200\ k + 5\ k} = 3.22\ V$

$V_C = 3.22 + 0.7 = 3.92\ V$

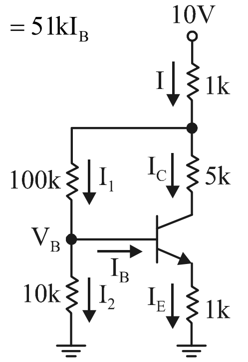
$\Rightarrow V_{EB} = -3.22$ (逆偏)，$V_{CB} = 0.7\ V$ (順偏)

$\Rightarrow$ 電晶體工作在反向主動區

33. 電晶體當成開關使用，當輸入信號 5 V 時要確保電晶體進入飽和區，即 $\beta \times I_B \geq I_{C(sat)}$，即

$$100 \times \frac{5 - 0.7}{R_B} \geq \frac{10 - 0.2}{0.25\ k} \Rightarrow R_B \leq 10.97\ k\Omega$$

34. $I_C = \beta I_B = 50 I_B$，$I_E = 51 I_B$，$V_E = 51k I_B$



$V_B = V_{BE} + V_E = 0.7 + 51k I_B$

$I_1 = I_2 + I_B = \frac{0.7 + 51k I_B}{10k} + I_B$

$I = I_C + I_1 = 51 I_B + \frac{0.7 + 51k I_B}{10k}$

$10 = I \times 1k + I_1 \times 100k + V_B$

$\Rightarrow 10 = (51 I_B + \frac{0.7 + 51k I_B}{10k}) \times 1k$

$+ (\frac{0.7 + 51k I_B}{10k} + I_B) \times 100k + 0.7 + 51k I_B$

解得 $I_B = 3.11 \times 10^{-3}\ mA$，$I = 0.244\ mA$

$\therefore V_A = 10 - I \times 1\ k = 9.756\ V$

35. 由 Q 點可看出 $I_C = 1.5\ mA$，$V_{CE} = 5\ V$

$I_B = \frac{I_C}{\beta} = \frac{1.5\ m}{100} = 15\ \mu A$

$I_B = \frac{(5 - 0.7)}{R_B}$，$R_B = 287\ k\Omega$

36. $I_C = \alpha I_E = 0.99 \times \frac{5 - 0.7}{1\ k + \frac{10\ k}{101}} = 3.87\ mA$

$I_{C(sat)} = \frac{15 - 0.2}{1\ k + 5\ k} = 2.47\ mA \leq I_C$，$\therefore$已飽和

$5 = 10\ k I_B + 0.7 + (I_B + I_{C(sat)}) \times 1\ k$ ……①

$15 = 5\ k I_{C(sat)} + 0.2 + (I_B + I_{C(sat)}) \times 1\ k$ ……②

解得 $I_B = 169.23\ \mu A$

37. $V_B = 10 \times \frac{10\ k}{40\ k + 10\ k} = 2\ V$，$V_E = 2 - 0.7 = 1.3\ V$

$I_E = \frac{1.3}{1\ k} = 1.3\ mA$，$r_e = \frac{26\ m}{1.3\ m} = 20\ \Omega$

$A_V = \frac{-(3\ k \,//\, 1\ k)}{20} = -37.5$

38. $A_i = \left|\frac{I_o}{I_i}\right| = \frac{I_o}{I_e} \times \frac{I_e}{I_b} \times \frac{I_b}{I_i}$

$$= \frac{I_e}{I_e} \times (1 + \beta) \times \frac{I_i \times \frac{270\ k}{270\ k + 151 \times 2\ k}}{I_i} = 71.28$$

39. 高漏電流

40. $10\log\frac{32}{2}=10\log 2^4\cong 12\ \text{dB}$

41. $V_{GS}>V_T$ 且 $V_{DS}\geq V_{GS}-V_T$

$\therefore m=\frac{V_{DS}}{V_{GS}-V_T}\geq 1$ 在第II區

42. $0.5I_{DSS}=I_{DSS}(1-\frac{V_{GS}}{V_{GS(off)}})^2 \Rightarrow V_{GS}=0.293\ V_{GS(off)}$

43. 空乏型 MOSFET 工作時，閘極可加正或負偏壓

44. $I_D=8(1-\frac{-I_D\cdot 1}{V_{GS(off)}})^2 \Rightarrow I_D=2\ \text{mA}$

$g_m=|\frac{2}{V_{GS(off)}}|\sqrt{I_D\times I_{Dss}}=2\ \text{mA/V}$

$A_V=-g_mR_D=-8$

45. $Z_i=47\ k\ //\ 47\ k=23.5\ k\Omega$

爲一分壓式偏壓共汲極放大電路

$A_V=\frac{6\ k\ //\ 3\ k}{\frac{1}{g_m}+6\ k\ //\ 3\ k}=0.5$，$A_i=A_V\times\frac{23.5\ k}{3\ k}=3.92$

46. $R_i=\frac{V_i}{I_i}=\frac{V_i}{\frac{V_i-V_o}{R}}=\frac{V_i}{\frac{V_i-V_i(1+\frac{R_1}{R_2})}{R}}$

$=-R\frac{R_2}{R_1}=-100\ k\Omega$

47. $V_o=-2\times\frac{10\ k}{1\ k}=-20\ V$ (輸出已經負飽和)

$\therefore V_o=-15\ V$

48. $V_o=-RC\frac{dV_i}{dt}$，V_o電壓與 R 成正比

49. $V_U=\frac{V_{sat}R_1}{R_1+R_2}$，$V_L=\frac{-V_{sat}R_1}{R_1+R_2}$

$\Rightarrow V_H=V_U-V_L=\frac{2V_{sat}R_1}{R_1+R_2}$

50. $f=\frac{1}{T}=\frac{1}{0.693(R_1+2R_2)C}$

$=\frac{1}{0.693(50\ k+2\times 47\ k)(1\ \mu)}\cong 10\ \text{Hz}$