# 2009년 국가직 7급 회로이론 봉책형 해설

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|---|---|---|---|---|---|---|---|---|---|
| 01. ① | 02. ① | 03. ④ | 04. ④ | 05. ① | 06. ③ | 07. ④ | 08. ① | 09. ④ | 10. ② |
| 11. ④ | 12. ② | 13. ④ | 14. ③ | 15. ② | 16. ③ | 17. ② | 18. ③ | 19. ② | 20. ① |

1. 【정답】 ①

$$z_{11}=\left.\frac{\mathrm{V}_1}{\mathrm{I}_1}\right|_{\mathrm{I}_2=0}=2-j4\,[\Omega],\ z_{12}=\left.\frac{\mathrm{V}_1}{\mathrm{I}_2}\right|_{\mathrm{I}_1=0}=\frac{-j4\mathrm{I}_2}{\mathrm{I}_2}=-j4\,[\Omega]$$

$$z_{21}=\left.\frac{\mathrm{V}_2}{\mathrm{I}_1}\right|_{\mathrm{I}_2=0}=\frac{-j4\mathrm{I}_1}{\mathrm{I}_1}=-j4\,[\Omega],\ z_{22}=\left.\frac{\mathrm{V}_2}{\mathrm{I}_2}\right|_{\mathrm{I}_1=0}=\frac{(j2-j4)\mathrm{I}_2}{\mathrm{I}_2}=-j2\,[\Omega]$$

2. 【정답】 ①

$$H(s)=\frac{10\left(1+\frac{s}{1}\right)}{10s\left(1+\frac{s}{10}\right)}=\frac{\left(1+\frac{s}{1}\right)}{s\left(1+\frac{s}{10}\right)}$$

$\omega<1$일 때 $H(s)=\frac{1}{s}$이므로 기울기 $-20$이다.

$1<\omega\le 10$일 때 $H(s)=\frac{\left(1+\frac{s}{1}\right)}{s}$이므로 기울기 $0$이다.

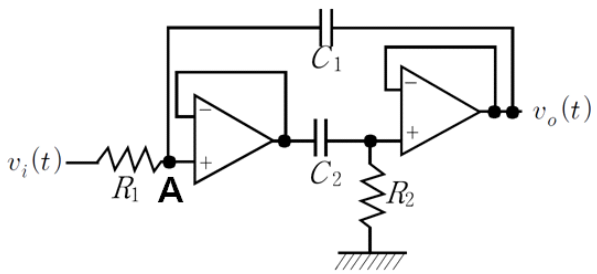
$\omega>10$일 때 $H(s)=\frac{\left(1+\frac{s}{1}\right)}{s\left(1+\frac{s}{10}\right)}$이므로 기울기 $+20$이다.

따라서 전달함수의 크기 특성을 나타낸 보드선도는 ①번이다.

3. 【정답】 ④

$$R_L=R_{\mathrm{Th}}=20\parallel 10+20\parallel 10=\frac{200}{30}+\frac{200}{30}=\frac{40}{3}\,[\Omega]$$

4. 【정답】 ④



$$\frac{V_i - V_A}{R_1} = \frac{V_A - V_o}{\frac{1}{sC_1}},\quad V_i = (sC_1R_1+1)V_A - sC_1R_1V_o$$

$$\frac{V_A - V_o}{\frac{1}{sC_2}} = \frac{V_o}{R_2},\quad V_A = \frac{sC_2R_2+1}{sC_2R_2}V_o$$

$$V_i = \frac{(sC_1R_1+1)(sC_2R_2+1)}{sC_2R_2}V_o - sC_1R_1V_o$$

$$\frac{V_o}{V_i} = \frac{1}{\frac{(sC_1R_1+1)(sC_2R_2+1)}{sC_2R_2} - sC_1R_1} = \frac{sC_2R_2}{(sC_1R_1+1)(sC_2R_2+1) - s^2C_1C_2R_1R_2}$$

$$\frac{V_o}{V_i} = \frac{sC_2R_2}{s(C_1R_1+C_2R_2)+1}$$

$\omega < \frac{1}{C_1R_1+C_2R_2}$일 때 $\frac{V_o}{V_i} = sC_2R_2$이므로 기울기 20이다.

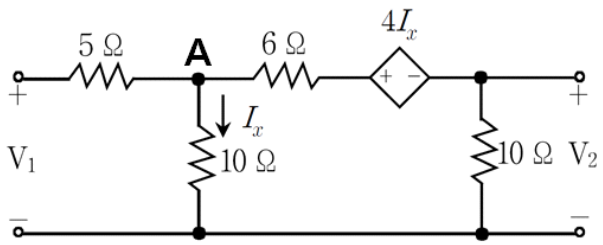
$\omega \geq \frac{1}{C_1R_1+C_2R_2}$일 때 $\frac{V_o}{V_i} = \frac{sC_2R_2}{s(C_1R_1+C_2R_2)+1}$이므로 기울기 0이다.

따라서 $\left|\frac{V_o(j\omega)}{V_i(j\omega)}\right|$를 나타낸 보드선도는 ④번이다.

5. **【정답】** ①

$$R_{ab} = ((3 \parallel 6)+4) \parallel 4 \parallel 12 + 5$$
$$R_{ab} = 6 \parallel 4 \parallel 12 + 5$$
$$R_{ab} = 6 \parallel 3 + 5$$
$$R_{ab} = 2 + 5 = 7\,[\Omega]$$

6. **【정답】** ③




$$V_A = 10I_x$$

$$I_1 = I_x + \frac{10I_x - (V_2 + 4I_x)}{6},\quad I_2 = -\frac{10I_x - (V_2 + 4I_x)}{6}$$

$V_2 = 0$일 때, $I_2 = 2I_x$, $I_2 = -I_x$이므로

$$h_{21} = \left.\frac{I_2}{I_1}\right|_{V_2=0} = \frac{-I_x}{2I_x} = -0.5$$

7. 【정답】 ④

$$10 - 2i(t) - v_C(t) = 0$$

$$i(t) = \frac{v_C(t)}{2} + 0.1\frac{dv_C(t)}{ct}$$

$v_C(t) = 10 - 2i(t)$이므로

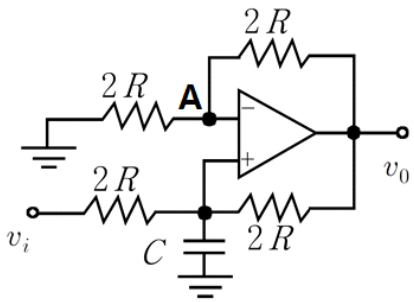
$$i(t) = 5 - i(t) + 0.1\frac{d(10-2i(t))}{dt} = 5 - i(t) - 0.2\frac{di(t)}{dt}$$

$$0.2\frac{di(t)}{dt} + 2i(t) = 5, \quad \frac{di(t)}{dt} + 10i(t) = 25$$

$$i(0) = \frac{4}{2} = 2\,[\mathrm{mA}], \quad i(\infty) = \frac{10}{2+2} = 2.5\,[\mathrm{mA}]$$이므로

$$i(t) = 2.5 + (2.5-2)e^{-10t} = 2.5 + 0.5e^{-10t}\,[\mathrm{mA}]$$

8. 【정답】 ①




$$\frac{V_o - V_A}{2R} = \frac{V_A}{2R}, \quad V_o = 2V_A$$

$$\frac{V_o - V_A}{2R} = \frac{V_A}{\frac{1}{sC}} + \frac{V_A - V_i}{2R}$$

$$\frac{V_A}{2R} = sCV_A + \frac{V_A - V_i}{2R}, \quad V_i = 2sRCV_A$$

$V_o = 2V_A$이므로 $V_i = sRCV_o$, $V_o = \frac{1}{sRC}V_i$

라플라스 역변환하면 $v_o = \frac{1}{RC}\int v_i dt$

9. 【정답】 ④

$t<0$에서 $\dfrac{4i_o(t)-24}{3}=i_o(t)$이므로 $i_0(t)=24\,[\mathrm{A}]$이다.

이때, $i_1(t)=\dfrac{4i_o(t)}{2}=2i_o(t)=48\,[\mathrm{A}]$

따라서 $t=0$에서 $0.5\mathrm{H}$ 인덕터의 영향은 없으므로 $i_1(0)=48\,[\mathrm{A}]$

$t<0$에서 $3\mathrm{F}$ 커패시터 양단의 전위차는 $4i_o(t)=96\,[\mathrm{A}]$이고, $t=0$에서 반대방향으로 전위차가 생기므로 $i_2(0)=\dfrac{-96}{6}=-16\,[\mathrm{A}]$

10. 【정답】 ②

$$I(s)=\frac{V(s)}{2s+\dfrac{s}{s+1}+2}\times\frac{s}{s+1}=\frac{s\,V(s)}{2s(s+1)+s+2(s+1)}$$

$$I(s)=\frac{s\,V(s)}{2s^2+5s+2}$$

$v(t)=100u(t)-100u(t-0.5)$이므로 $V(s)=\dfrac{100}{s}\left(1-e^{-0.5s}\right)$

$$I(s)=\frac{s\times\dfrac{100}{s}\left(1-e^{-0.5s}\right)}{2s^2+5s+2}=\frac{100}{2s^2+5s+2}\left(1-e^{-0.5s}\right)$$

11. 【정답】 ④

전달함수는 임펄스 응답의 라플라스 변환이므로 $H(s)=\dfrac{1}{s+1}$

$$V_0(s)=\frac{1}{s+1}\times\frac{10}{s+2}=10\left(\frac{1}{s+1}-\frac{1}{s+2}\right)[\mathrm{V}]$$

$$v_0(t)=10\left(e^{-t}-e^{-2t}\right)[\mathrm{V}]$$

12. 【정답】 ②

$$F(s)=\frac{2s+1}{s^2+1}=\frac{1}{s^2+1}+2\frac{s}{s^2+1}$$

$$f(t)=\sin t+2\cos t$$

13. 【정답】 ④

$$H(jw)=\frac{2}{jw+2+\dfrac{1}{0.5jw}}=\frac{2jw}{-w^2+2jw+2}=\frac{j2w}{2-w^2+j2w}$$

14. 【정답】 ③

$$10-\frac{1}{20}i(t)-0.01\frac{di(t)}{dt}=0$$

$$\frac{di(t)}{dt}+5i(t)=10^3$$

$$i(t)=200\left(1-e^{-5t}\right)$$

$$v_L=0.01\times1000e^{-5t}=10e^{-5t}\,[\mathrm{V}],\ v_R=10\left(1-e^{-5t}\right)[\mathrm{V}]$$

15. 【정답】 ②

폐루프 전달함수 $\frac{A(s)}{1+A(s)\beta(s)}$이므로 특성방정식은 $1+A(s)\beta(s)=0$이다.

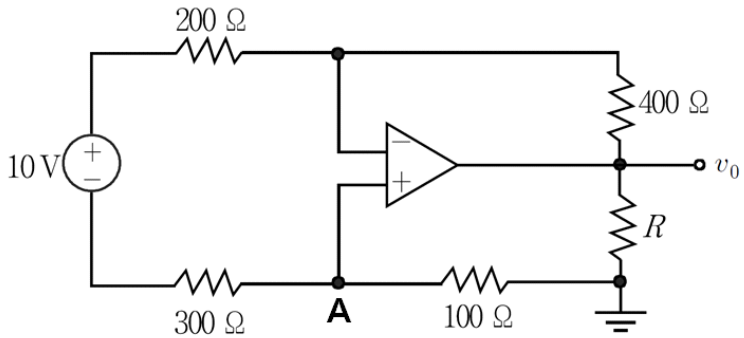
$$1+A(s)\beta(s)=1+\frac{-ks}{s^2+3s+1}=0$$

$$s^2+(3-k)s+1=0$$

전달함수의 특성방정식의 계수가 모두 양수이어야 안정하므로

$3-k>0,\ k<3$

16. 【정답】 ③




$$\frac{v_A-v_0}{400}=\frac{0-v_A}{100},\ v_0=5v_A$$

$$-\left(-\frac{v_A}{100}\right)\cdot300+10-\left(-\frac{v_A}{100}\right)\cdot200=0$$ (연산증폭기의 입력전압이 같을 조건)

$5v_A=-10,\ v_A=-2\,[\mathrm{A}]$

$v_0=5\cdot(-2)=-10\,[\mathrm{V}]$

17. 【정답】 ②

n번째 반복하였을 때 등가저항을 $\mathrm{R_n}$이라 하면

$\mathrm{R}+2\mathrm{R}\parallel\mathrm{R_n}=\mathrm{R_{n+1}}$의 관계가 성립한다.

$R + \frac{2R R_n}{2R + R_n} = R_{n+1}$, 이때 $\lim_{n\to\infty} R_n = \alpha$라 하면

$R + \frac{2R\alpha}{2R + \alpha} = \alpha$

$R(2R + \alpha) + 2R\alpha = \alpha(2R + \alpha)$

$\alpha^2 - R\alpha - 2R^2 = 0$

$(\alpha - 2R)(\alpha + R) = 0$

$\alpha > 0$이므로 $\alpha = 2R$

$R_{eq} = \alpha = 2R$

18. 【정답】 ③

$\frac{V_x}{3} + 2V_x + \frac{V_o}{\frac{1}{3s}} = 0, \ V_o = -\frac{7}{9s} V_x$

$\frac{V_x}{3} = \frac{V_o - V_x - V_i}{3s}, \ V_o = V_i + (s+1) V_x$

$V_o = V_i + (s+1)\left(-\frac{9s}{7} V_o\right)$

$\frac{V_o(s)}{V_i(s)} = \frac{1}{1 + (s+1)\left(\frac{9s}{7}\right)} = \frac{7}{9s^2 + 9s + 7}$

19. 【정답】 ②

$kV_o + 10I_x = \frac{V_o}{1} + \frac{V_o}{\frac{1}{0.5s}}, \ I_x = \frac{1 + 0.5s - k}{10} V_o$

$V_i - (kV_o + I_x) \cdot 1 - 10I_x = 0$

$V_o + \frac{11}{k} I_x = \frac{V_i}{k}, \ \left(1 + \frac{11}{k}\left(\frac{1 + 0.5s - k}{10}\right)\right) V_o = V_i$

$\frac{V_o(s)}{V_i(s)} = \frac{1}{1 + \frac{11}{k}\left(\frac{1 + 0.5s - k}{10}\right)} = \frac{10k}{10k + 11(1 + 0.5s - k)} = \frac{10k}{5.5s - k + 11}$

극점인 $\frac{k - 11}{5.5} < 0$이어야 하므로 $k < 11$

따라서 $k$값의 최대 범위는 $0 < k < 11$

20. 【정답】 ①

$v_{TH} = v_{ab} = v_1 = 6 \cdot (-10i_1) = -60i_1$

$i_1 = \dfrac{10-2v_1}{20} = \dfrac{10-2v_{TH}}{20} = \dfrac{10+120i_1}{20}$

식을 풀면 $i_1 = -0.1\,[\mathrm{A}]$, $v_{TH} = (-60)(-0.1) = 6\,[\mathrm{V}]$

단락전류 $i_{sc}$를 구하기 위해 ab를 단락시키면

$i_{sc} = i_{ab} = \dfrac{6}{3+6} \times 10i_1 = \dfrac{20}{3}i_1$

이때 $v_{TH} = 0$이므로 $i_1 = \dfrac{10}{20} = 0.5\,[\mathrm{A}]$, $i_{sc} = \dfrac{10}{3}\,[\mathrm{A}]$

$R_{TH} = \dfrac{v_{TH}}{i_{sc}} = \dfrac{6}{\frac{10}{3}} = \dfrac{18}{10} = 1.8\,[\Omega]$