회로이론1 2018년 2학기 중간 모범 답안

이시영
전용현

1.

yellow : 4 green : 5 red : 2 금색 : ±5%

$\therefore 45 \times 10^2 \Omega$ 오차 : ±5%

2.

$R_{ab} = 5 + (4 // (0 // 3)) = 5 + 0 = 5\Omega$

$R_{cd} = 6 + (3 // (0 // 4)) = 6 + 0 = 6\Omega$

3.

등가저항 : $4 + (2 // (0 // 6)) = 4 + 0 = 4\Omega$

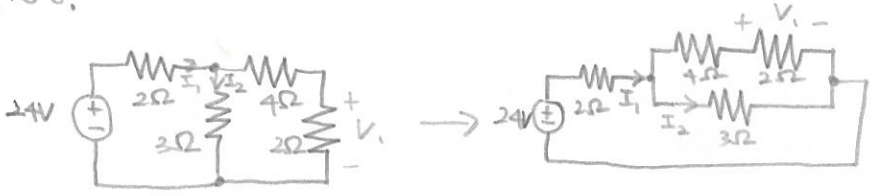
$\therefore I_1 = \frac{8V}{4k\Omega} = 2mA$

$I_1 = I_3 = I_4 = 2mA$, $I_2 = I_5 = I_6 = 0$

4.

$V_1 = V_2 = V_3 = V_4 = 0$

5.~8.



$R_{eq} = 2 + (3 // (4+2))$
$= 2 + 2 = 4\Omega$

5.

$I_1 = \frac{24}{4} = 6[A]$

$I_2 = 6 \times \frac{2}{3} = 4[A]$

6.

$V_1 = 24 \times \frac{1}{2} \times \frac{1}{3} = 4V$

7.

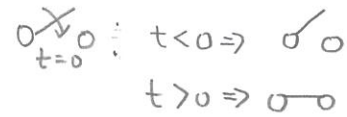
$P = IV = I^2R$ ($\because V = IR$)

$= I_2^2 \times 3 = 16 \times 3 = 48\ W$

8.

$48 \times 10 = 480\ Wh$

9.~11.



9.

$t<0$ 일때 $I_1' = \frac{4}{3}$ [A]

$t>0$ 일때 $I_1'' = \frac{40}{10+(20//20)} = \frac{40}{20} = 2$ [A]

$\therefore \frac{4}{3} : 2 = 2 : 3$

10.

$t<0$ 일때 $I_2' = \frac{4}{3}$ [A]

$t>0$ 일때 $I_2'' = \frac{40}{10+(20//20)} \times \frac{1}{2} = 1$ [A]

$\therefore \frac{4}{3} : 1 = 4 : 3$

11.

$t<0$ 일때 소모전력 $I_1'^2 R$

$t>0$ 일때 소모전력 $I_1''^2 R$

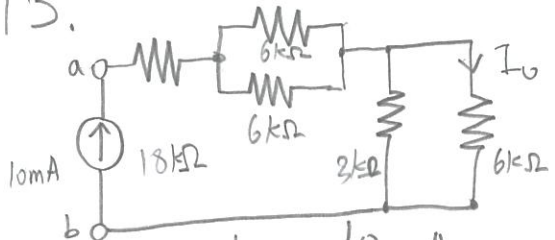
$\therefore I_1'^2 R : I_1''^2 R = I_1'^2 : I_1''^2 = 4 : 9$

12.

$R_{eq} = 10k\Omega$

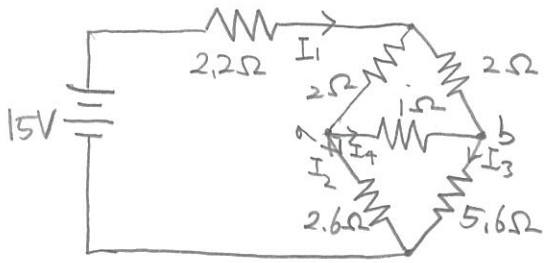
$I_o = \frac{20}{10k} \times \frac{1}{3} = \frac{20}{3}$ mA

13.



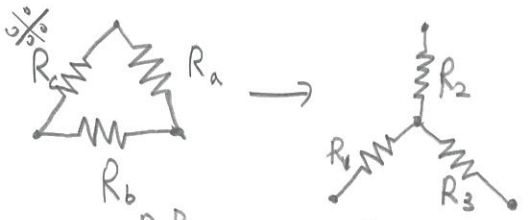
$I_o = 10 \times \frac{1}{3} = \frac{10}{3}$ mA

14~16.



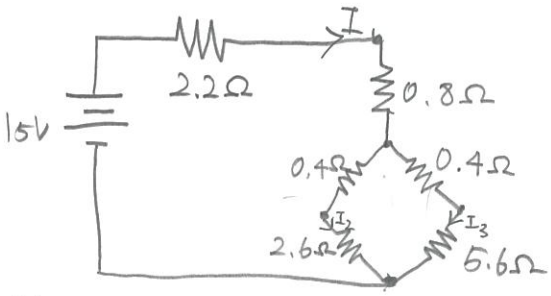
⇓

Δ→Y 변환



$R_1 = \frac{R_b R_c}{R_a+R_b+R_c}$ $R_2 = \frac{R_c R_a}{R_a+R_b+R_c}$ $R_3 = \frac{R_a R_b}{R_a+R_b+R_c}$

∴



14. $2.2\Omega + 0.8\Omega + (0.4\Omega + 2.6\Omega \,//\, 0.4\Omega + 5.6\Omega)$

$= 3\Omega + 2\Omega = 5\Omega = R_{eq}$

15. $I_1 = \frac{15V}{R_{eq}} = \frac{15}{5} = 3$ [A]

$I_2 = 3 \times \frac{2}{3} = 2$ [A]

$I_3 = 3 \times \frac{1}{3} = 1$ [A]

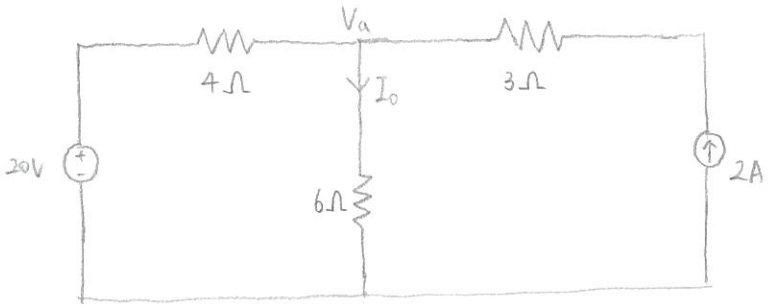
16.

a지점 전압 5.2V

b지점 전압 5.6V

$\therefore I_4 = \frac{5.2 - 5.6}{1} = -0.4$ A

17. 마디해석법으로 I_o를 구하시오



$\frac{20-Va}{4} = \frac{Va}{6} - 2$

$60 - 3Va = 2Va - 24$

$5Va = 84$

$Va = \frac{84}{5}$

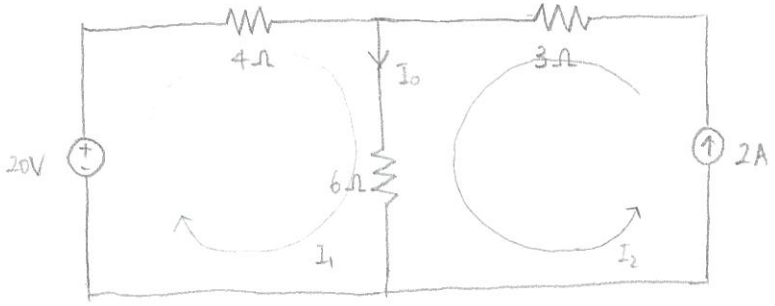
$6I_o = Va$

$I_o = Va \times \frac{1}{6}$

$I_o = \frac{84}{5} \times \frac{1}{6} = \frac{14}{5} = 2.8$

$I_o = 2.8\,A$

18. 루프해석법으로 I_o를 구하시오.



$I_2 = 2A$

$20 = 4I_1 + 6(I_1 + I_2)$

$20 = 4I_1 + 6I_1 + 12$

$10I_1 = 8$

$I_1 = \frac{8}{10} = 0.8$

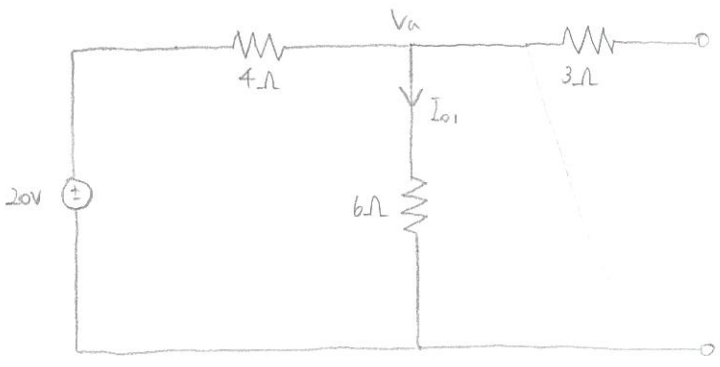
$I_o = I_1 + I_2$

$I_o = 0.8 + 2 = 2.8$

$I_o = 2.8\,A$

19. 중첩의 원리를 이용하여 I_o를 구하시오

전류원이 없을 때



$\frac{20-Va}{4} = \frac{Va}{6}$

$60 - 3Va = 2Va$

$5Va = 60$

$Va = 12$

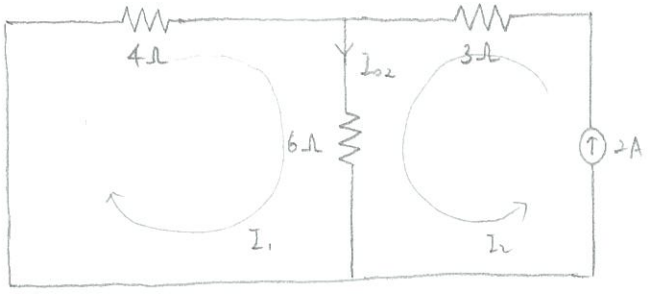
$\frac{Va}{6} = I_{o1}$

$I_{o1} = \frac{12}{6} = 2$

$I_{o1} = 2A$

19.

전압원이 없을 때



$I_2 = 2A$ $\quad I_{o2} = I_1 + I_2$

$4I_1 + 6(I_1 + I_2) = 0$

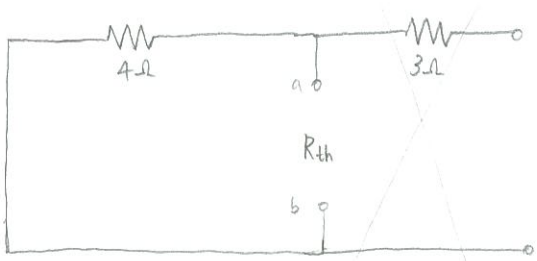
$10I_1 + 12 = 0$

$I_1 = -\frac{12}{10} = -1.2$

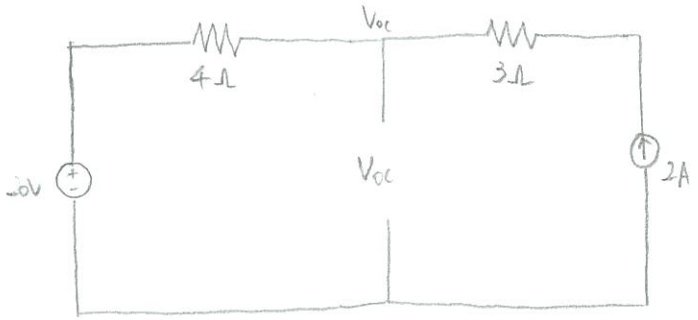
$I_{o2} = -1.2 + 2 = 0.8$ $\quad \underline{I_{o2} = 0.8A}$

$I_o = I_{o1} + I_{o2} = 2 + 0.8 = 2.8$ $\quad \underline{I_o = 2.8A}$

20. 테브난 정리를 이용하여 I_o를 구하시오.



$R_{eq} = 4\Omega$



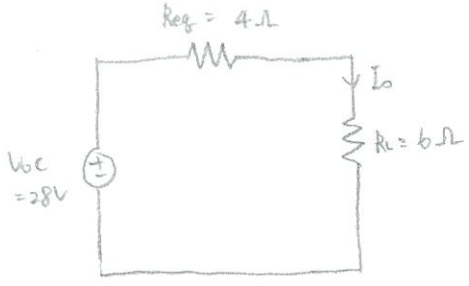
$\frac{20 - V_{oc}}{4} = -2$

$20 - V_{oc} = -8$

$V_{oc} = 28$

$V_{oc} = 28V$

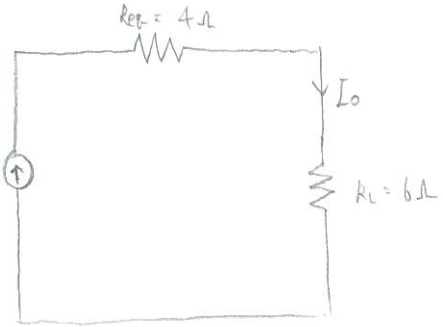
테브난 정리에 의해서



$I_o = \frac{28}{10} = 2.8$

$\underline{I_o = 2.8A}$

21. 노튼의 정리를 이용해서 I_o를 구하시오



노튼의 정리에 의해서

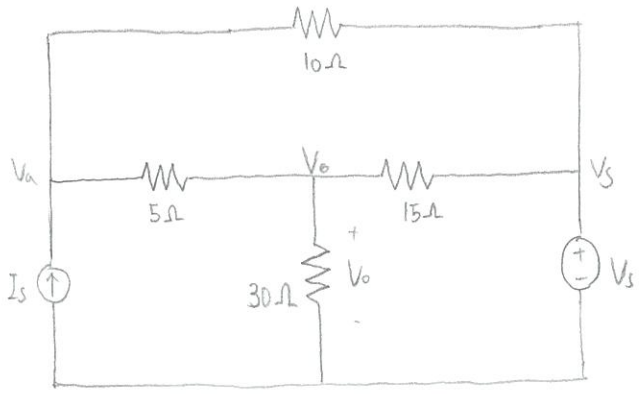
$i_{oc} = \frac{V_{oc}}{R_{eq}}$

$= 2.8A$

$i_{oc} = 2.8A$

$\underline{I_o = 2.8A}$

22. 마디해석법으로 V_o를 I_s와 V_s의 함수로 나타내시오



① $\frac{V_a - V_o}{5} = \frac{V_o}{30} + \frac{V_o - V_s}{15}$

$6V_a - 6V_o = V_o + 2V_o - 2V_s$

$9V_o = 6V_a + 2V_s$

② $\frac{V_s - V_a}{10} = \frac{V_a - V_o}{5} - I_s$

$V_s - V_a = 2V_a - 2V_o - 10I_s$

$2V_o = 3V_a - V_s - 10I_s$

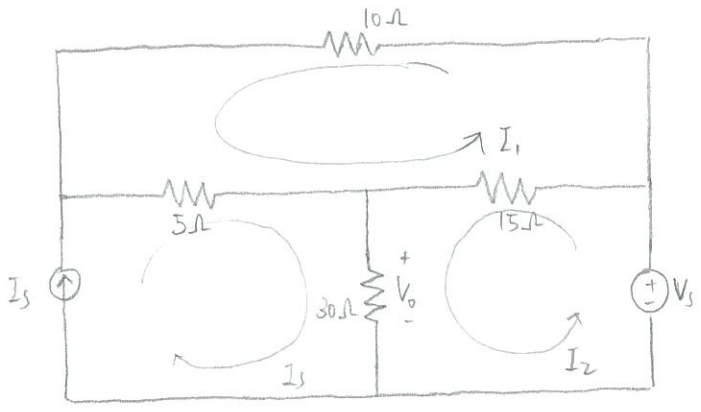
$9V_o = 6V_a + 2V_s$

$-\ 4V_o = 6V_a - 2V_s - 20I_s$

$5V_o = 4V_s + 20I_s$

$$V_o = \frac{4}{5}V_s + 4I_s$$

23. 루프해석법으로 V_o를 I_s와 V_s의 함수로 나타내시오.



$V_o = 30(I_s + I_2)$

① $10I_1 + 5(I_1 + I_s) + 15(I_1 - I_2) = 0$

$30I_1 - 15I_2 = -5I_s$

② $15(I_2 - I_1) + 30(I_2 + I_s) = V_s$

$-15I_1 + 45I_2 = V_s - 30I_s$

$30I_1 - 15I_2 = -5I_s$

$-30I_1 + 90I_2 = 2V_s - 60I_s$

$75I_2 = 2V_s - 65I_s$

$$I_2 = \frac{2}{75}V_s - \frac{65}{75}I_s$$

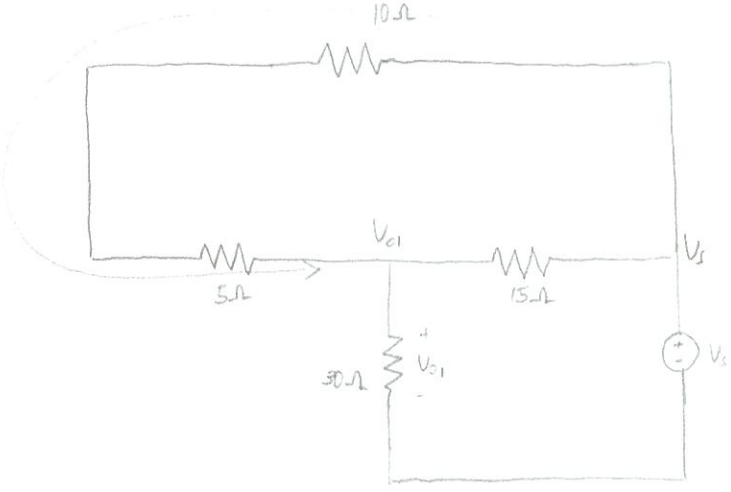
$$V_o = 30\left(I_s + \frac{2}{75}V_s - \frac{65}{75}I_s\right)$$

$$= \frac{4}{5}V_s + 4I_s$$

$$V_o = \frac{4}{5}V_s + 4I_s$$

24. 중첩의 원리를 이용하여 V_o를 I_s와 V_s의 함수로 나타내시오

전류원이 없을 때



① $\frac{V_s - V_{o1}}{10+5} = \frac{V_{o1} - V_s}{15} + \frac{V_{o1}}{30}$

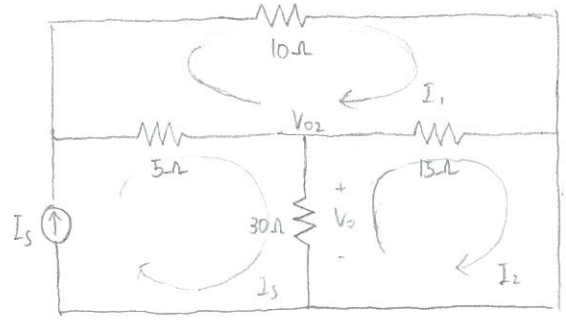
$2V_s - 2V_{o1} = 2V_{o1} - 2V_s + V_{o1}$

$5V_{o1} = 4V_s$

$$V_{o1} = \frac{4}{5}V_s$$

24.

전압원이 없을 때



① $10I_1 + 15(I_1 - I_2) + 5(I_1 - I_S) = 0$

$30I_1 - 15I_2 = 5I_S$

② $15(I_2 - I_1) + 30(I_2 - I_S) = 0$

$-15I_1 + 45I_2 = 30I_S$

$30I_S - 15I_2 = 5I_S$

$+ \quad -30I_S + 90I_2 = 60I_S$

$75I_2 = 65I_S$

$I_2 = \frac{13}{15} I_S$

$V_{o_2} = 30(I_S - I_2)$

$= 30\left(I_S - \frac{13}{15}I_S\right)$

$= 30\left(\frac{2}{15}I_S\right)$

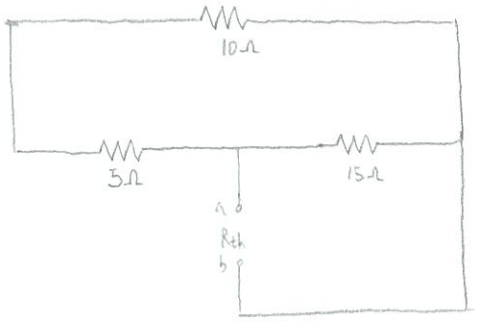
$V_{o2} = 4I_S$

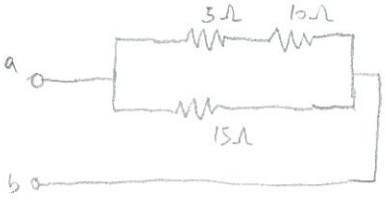
$V_o = V_{o1} + V_{o2}$

$= \frac{4}{5}V_S + 4I_S$

$V_o = \frac{4}{5}V_S + 4I_S$

25. 테브난의 정리를 이용하여 V_o를 I_S와 V_S의 함수로 나타내시오



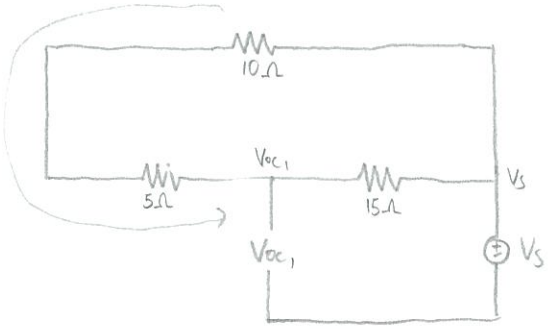


$Req = 15 \,//\, 15$

$\frac{225}{30} = \frac{75}{10} = 7.5$

$Req = 7.5\,\Omega$

전류원이 없을 때



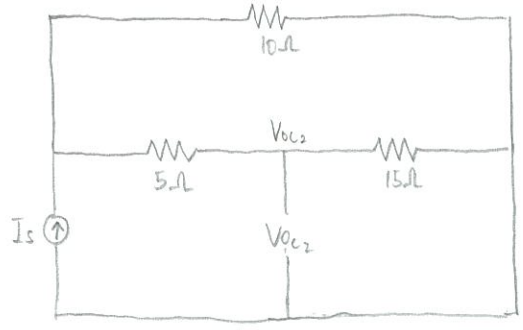
$\frac{V_S - V_{oc_1}}{10+5} = \frac{V_{oc_1} - V_S}{15}$

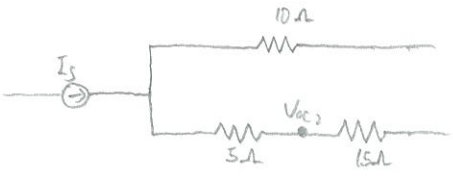
$V_S - V_{oc1} = V_{oc1} - V_S$

$2V_S = 2V_{oc1}$

$V_{oc1} = V_S$

전압원이 없을 때





$V_{oc_2} = \frac{1}{3} \times I_S \times 15 = 5I_S$

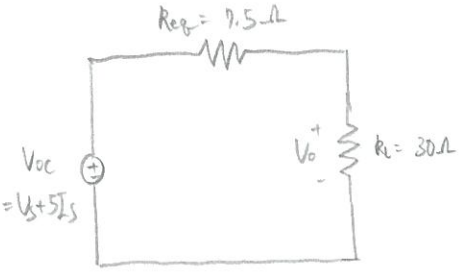
$V_{oc_2} = 5I_S$

$V_{oc} = V_{oc_1} + V_{oc_2} = V_S + 5I_S$

$V_{oc} = V_S + 5I_S$

25.

테브난 정리에 의해서



$$V_o = \frac{7.5}{30+7.5} V_{oc}$$

$$= \frac{30}{37.5} \times (V_s + 5I_s)$$

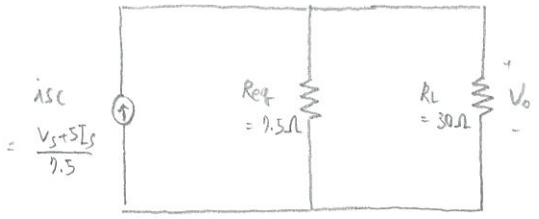
$$= \frac{4}{5}V_s + 4I_s$$

$$V_o = \frac{4}{5}V_s + 4I_s$$

26. 노튼의 정리를 이용하여 V_o를 I_s와 V_s의 함수로 나타내시오.

노튼의 정리에 의해서

$$i_{sc} = \frac{V_{oc}}{R_{eq}} = \frac{V_s + 5I_s}{7.5}$$



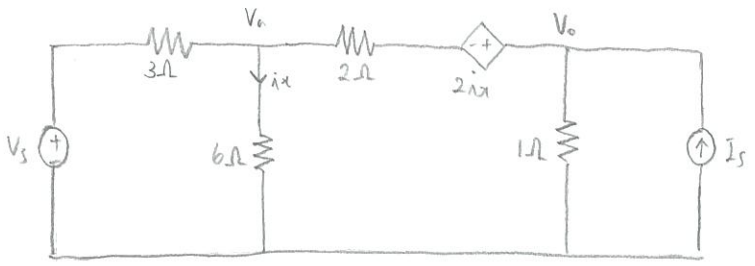
$$V_o = 7.5 // 30 \times i_{sc}$$

$$= \frac{225}{37.5} \times \frac{V_s + 5I_s}{7.5}$$

$$= \frac{4}{5}V_s + 4I_s$$

$$V_o = \frac{4}{5}V_s + 4I_s$$

27. 마디해석법으로 V_o를 I_s와 V_s의 함수로 나타내시오.



① $\frac{V_s - V_a}{3} = \frac{V_a}{6} + \frac{V_a - (V_o - 2ix)}{2}$

$2V_s - 2V_a = V_a + 3V_a - 3V_o + V_a$

$3V_o = 7V_a - 2V_s$

$ix = \frac{V_a}{6}$

② $\frac{V_a - (V_o - 2ix)}{2} = \frac{V_o}{1} - I_s$

$3V_a - 3V_o + V_a = 6V_o - 6I_s$

$9V_o = 4V_a + 6I_s$

연립

$12V_o = 28V_a - 8V_s$

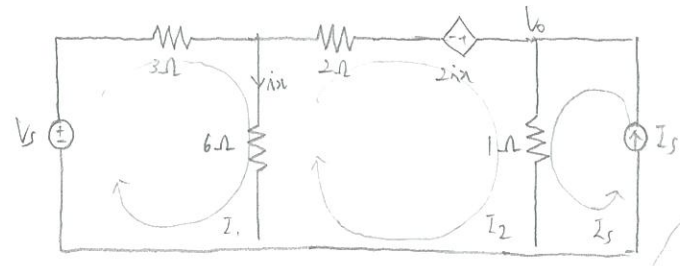
$63V_o = 28V_a + 42I_s$

$-51V_o = -8V_s - 42I_s$

$V_o = \frac{8}{51}V_s + \frac{42}{51}I_s$

$V_o = \frac{8}{51}V_s + \frac{14}{17}I_s$

28. 루프해석법으로 V_o를 I_s와 V_s의 함수로 나타내시오.



① $3I_1 + 6(I_1 - I_2) = V_s$

$9I_1 - 6I_2 = V_s$

② $6(I_2 - I_1) + 2I_2 - 2ix + I_2 + I_3 = 0$

$8I_1 - 11I_2 = I_3$

$ix = I_1 - I_2$

연립

$72I_1 - 48I_2 = 8V_s$

$72I_1 - 99I_2 = 9I_s$

$51I_2 = 8V_s - 9I_s$

$I_2 = \frac{8}{51}V_s - \frac{9}{51}I_s$

* $V_o = I_2 + I_s$

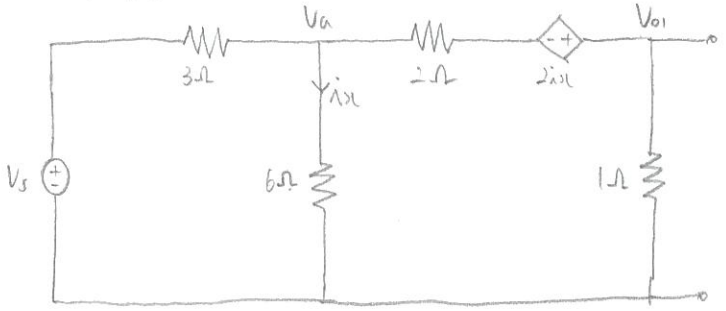
$V_o = \frac{8}{51}V_s - \frac{9}{51}I_s + I_s$

$V_o = \frac{8}{51}V_s + \frac{14}{17}I_s$

29. 중첩의 원리를 이용하여 V_o를 I_s와 V_s의 함수로 나타내시오

$i_x = \frac{V_a}{6}$

전류원이 없을 때



① $\frac{V_s - V_a}{3} = \frac{V_a}{6} + \frac{V_a - (V_{o1} - 2i_x)}{2}$

$2V_s - 2V_a = V_a + 3V_a - 3V_{o1} + V_a$

$\rightarrow 3V_{o1} = 7V_a - 2V_s$

② $\frac{V_a - (V_{o1} - 2i_x)}{2} = \frac{V_{o1}}{1}$

$3V_a - 3V_{o1} + V_a = 6V_{o1}$

$9V_{o1} = 4V_a$

대입.

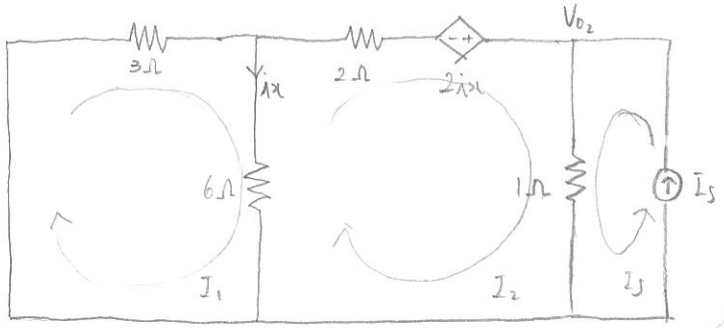
$V_a = \frac{9}{4}V_{o1}$

$3V_{o1} = \frac{63}{4}V_{o1} - 2V_s$

$\frac{51}{4}V_{o1} = 2V_s$

$V_{o1} = \frac{8}{51}V_s$

전압원이 없을 때



① $3I_1 + 6(I_1 - I_2) = 0$

$9I_1 - 6I_2 = 0$

$I_1 = \frac{2}{3}I_2$

$i_x = I_1 - I_2$

② $6(I_2 - I_1) + 2I_2 - 2i_x + I_2 + I_s = 0$

$\rightarrow 8I_1 - 11I_2 = I_s$

대입

$\frac{16}{3}I_2 - 11I_2 = I_s$

$-\frac{17}{3}I_2 = I_s \quad I_2 = -\frac{3}{17}I_s$

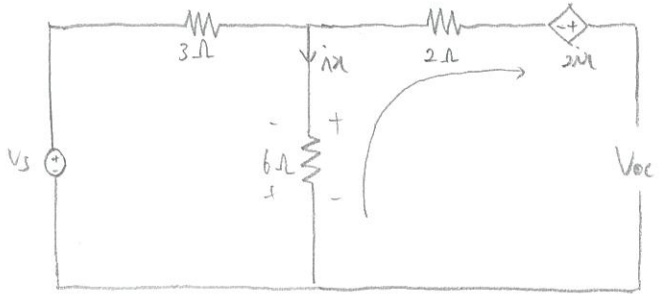
$*V_{o2} = I_2 + I_s$

$V_{o2} = \frac{14}{17}I_s$

$V_o = V_{o1} + V_{o2}$

$V_o = \frac{8}{51}V_s + \frac{14}{17}I_s$

30. 테브난의 정리를 이용하여 V_o를 I_s와 V_s의 함수로 나타내시오



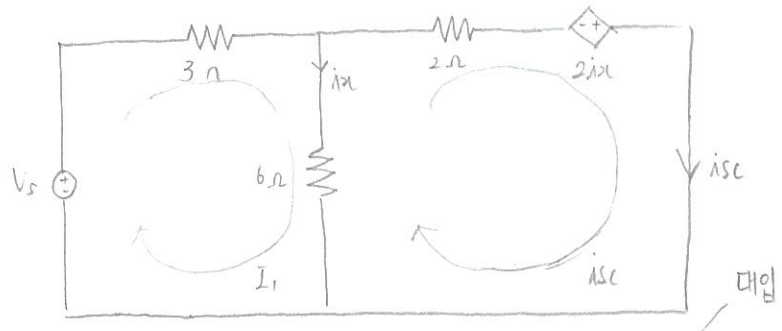
$V_{oc} = 6i_x + 2i_x$

$= 8i_x$

$i_x = \frac{1}{9}V_s$

$V_{oc} = \frac{8}{9}V_s$

30.



① $3I_1 + 6(I_1 - i_{sc}) = V_s$

$\rightarrow 9I_1 - 6i_{sc} = V_s$

$i_x = I_1 - i_{sc}$

② $6(i_{sc} - I_1) + 2i_{sc} - 2i_x = 0$

$10i_{sc} - 8I_1 = 0$

$I_1 = \frac{5}{4} i_{sc}$

대입

$\frac{45}{4} i_{sc} - 6i_{sc} = V_s$

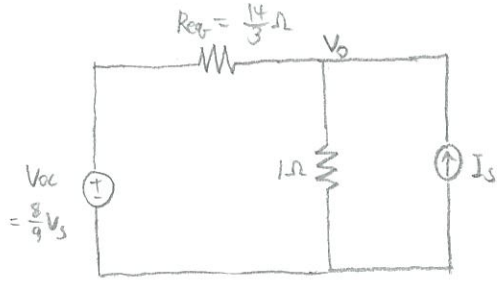
$\frac{21}{4} i_{sc} = V_s$

$i_{sc} = \frac{4}{21} V_s$

$R_{eq} = \frac{V_{oc}}{i_{sc}} = \frac{\frac{8}{9}V_s}{\frac{4}{21}V_s} = \frac{14}{3}$

$R_{eq} = \frac{14}{3}\Omega$

테브난 정리에 의해서



$\frac{V_{oc} - V_o}{\frac{14}{3}} = V_o - I_s$

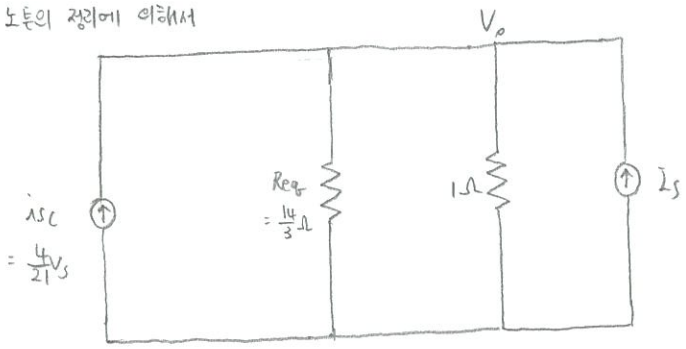
$\frac{4}{21}V_s - \frac{3}{14}V_o = V_o - I_s$

$\frac{17}{14}V_o = \frac{4}{21}V_s + I_s$

$V_o = \frac{8}{51}V_s + \frac{14}{17}I_s$

31. 노튼의 정리를 이용하여 V_o를 I_s와 V_s의 함수로 나타내시오.

노튼의 정리에 의해서



$V_{o1} = \frac{14}{3} /\!/ 1 \times I_s = \frac{14}{17}I_s$

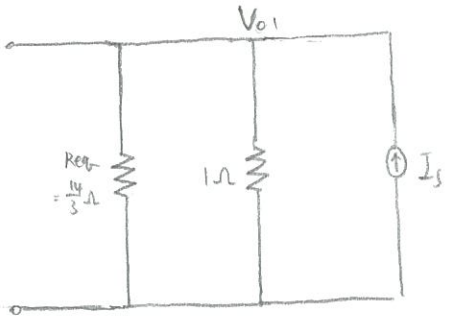
$V_{o2} = \frac{14}{3} /\!/ 1 \times \frac{4}{21}V_s = \frac{8}{51}V_s$

$V_o = V_{o1} + V_{o2}$

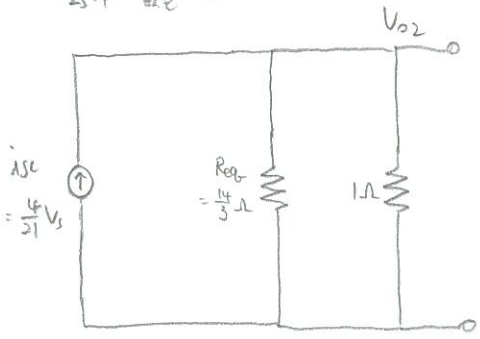
$V_o = \frac{8}{31}V_s + \frac{14}{17}I_s$

중첩의 원리를 이용

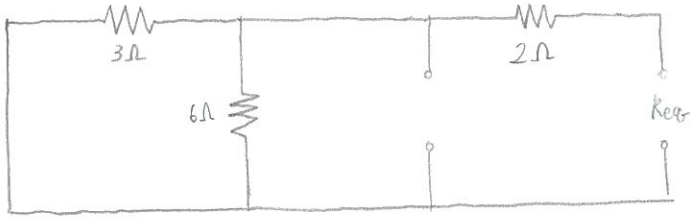
i_{sc}가 없을 때



I_s가 없을 때



32. 부하 R_L에 전달되는 전력이 최대이기 위한 R_L의 값은?

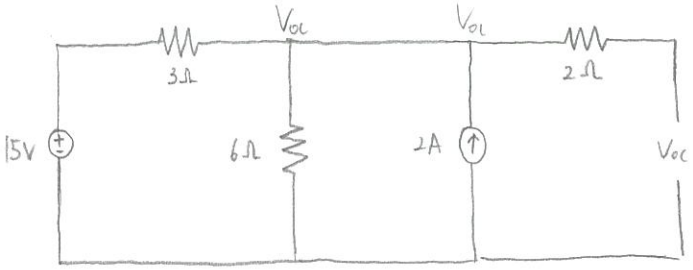


$R_{eq} = 2 + 3 // 6 = 4$

전력이 최대이기 위한 $R_L = R_{eq}$

$R_L = 4\Omega$

33. 부하 R_L에 전달되는 최대전력 $P_{L,max}$를 구하여라.



$\frac{15-V_{oc}}{3} = \frac{V_{oc}}{6} - 2$

$30 - 2V_{oc} = V_{oc} - 12$

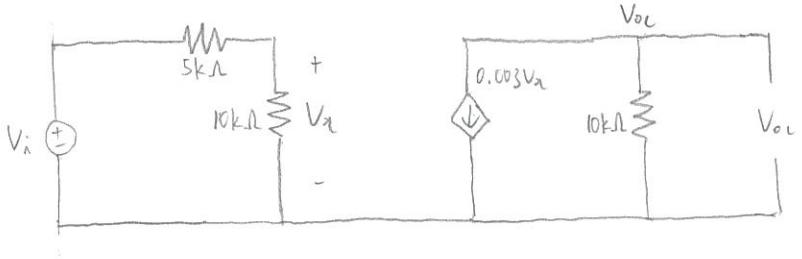
$3V_{oc} = 42$

$V_{oc} = 14V$

$P_{L,max} = \frac{(V_{oc})^2}{4 \cdot R_{eq}} = \frac{14 \cdot 14}{4 \cdot 4} = \frac{49}{4}$

$P_{L,max} = \frac{49}{4} W$

34. 단자 a, b에서 본 FET의 테브난의 등가회로를 구하여라

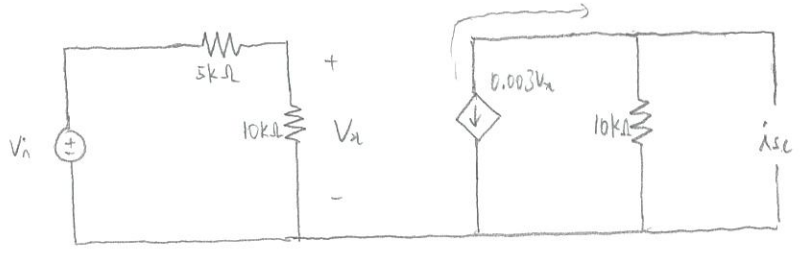


$V_{oc} = -0.003 V_x \times 10 \times 10^3$

$= -30 V_x$

$V_x = \frac{10}{10+5} V_i = \frac{2}{3} V_i$

$V_{oc} = -20 V_i$



$i_{sc} = -0.003 V_x$

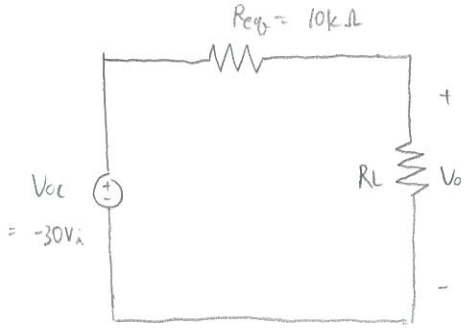
$V_x = \frac{2}{3} V_i$

$i_{sc} = -0.002 V_i$

$R_{eq} = \frac{V_{oc}}{i_{sc}} = \frac{-20 V_i}{-0.002 V_i} = 10 \times 10^3$

$R_{eq} = 10 k\Omega$

테브난 정리에 의하여



35. 부하 R_L에 전달되는 전력이 최대이기 위한 R_L의 값

전력이 최대이기 위한 $R_L = R_{eq}$ 이므로 $\underline{R_L = 10k\,\Omega}$

36. 부하 R_L에 전달되는 최대전력 $P_{L,max}$를 구하여라.

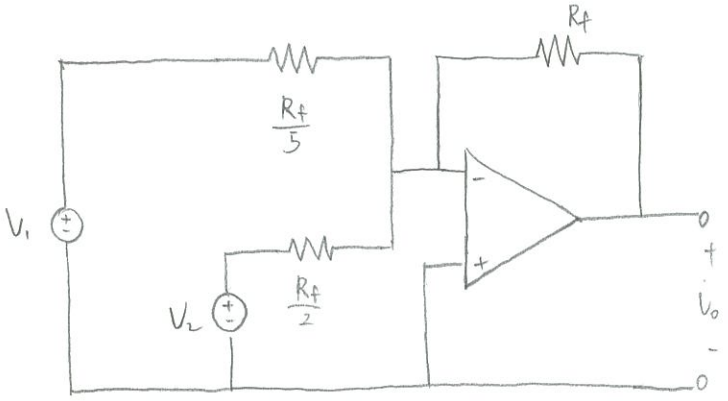
$$P_{L,max} = \frac{(V_{oc})^2}{4 \cdot R_{eq}} = \frac{400(V_i)^2}{4 \times 10k} \qquad \underline{P_{L,max} = 10(V_i)^2\ mW}$$

37. 부하에 최대 전력이 전달 될 때 전압이득 $\frac{V_o}{V_i}$를 구하시오.

앞의 테브난 정리에서 최대전력일 때 R_L이 $10k\Omega$ 이므로

$$V_o = \frac{1}{2}V_{oc} = -15V_i \qquad \frac{V_o}{V_i} = \frac{-15V_i}{V_i} = -15 \qquad \underline{\frac{V_o}{V_i} = -15}$$

38. V_o를 V_1과 V_2의 함수로 나타내시오

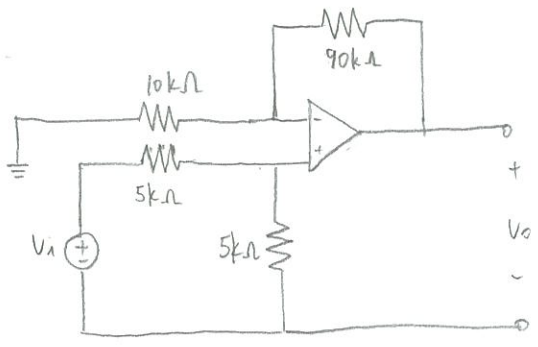


$$\frac{V_1 - 0}{\frac{R_f}{5}} + \frac{V_2 - 0}{\frac{R_f}{2}} = \frac{0 - V_o}{R_f}$$

$$5V_1 + 2V_2 = -V_o$$

$$\underline{V_o = -(5V_1 + 2V_2)}$$

39. 전압이득 $\frac{V_o}{V_i}$를 구하여라.



① $\frac{0 - V_-}{10k} = \frac{V_- - V_o}{90k}$

$-9V_- = V_- - V_o \qquad V_o = 10V_- \qquad V_- = \frac{1}{10}V_o$

② $\frac{V_i - V_+}{5k} = \frac{V_+ - 0}{5k}$ (KCL)

$V_i - V_+ = V_+ \qquad 2V_+ = V_i$

$^{*}V_- = V_+ \qquad \frac{1}{5}V_o = V_i$

$$\underline{\frac{V_o}{V_i} = 5}$$