

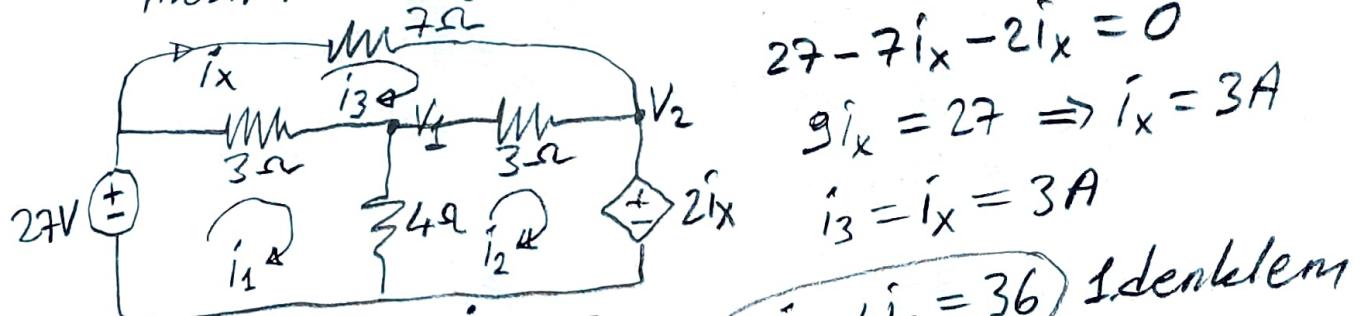
Node Analizi (KCL)  
yöntemini kullanarak  
 $V_1 = ?$ ,  $V_2 = ?$   
 $V_2 = 27 - 7i_x = 2i_x$   
 $9i_x = 27 \Rightarrow i_x = 3A$   
 $V_2 = 2i_x = 6V$

$$\frac{V_1 - 27}{3} + \frac{V_1}{4} + \frac{V_1 - V_2}{3} = 0 \quad \text{12 ile çarp}$$

$$4V_1 - 108 + 3V_1 + 4V_1 - 4V_2 = 0$$

$$11V_1 - 4V_2 = 108 \Rightarrow V_1 = \frac{108 + 4V_2}{11} = \frac{108 + 4 \times 6}{11} = \frac{132}{11} = 12V$$

Mesh Analizi (KVL) kullanarak iddi



$$27 - 7i_x - 2i_x = 0$$

$$9i_x = 27 \Rightarrow i_x = 3A$$

$$i_3 = i_x = 3A$$

$$27 - 7i_1 + 4i_2 + 3i_3 = 0 \Rightarrow 7i_1 - 4i_2 = 36 \quad \text{1. denklem}$$

$$27 - 7i_3 + 4i_2 + 9 = 0 \Rightarrow 7i_3 - 4i_2 + 9 = 0 \quad 7i_1 - 4i_2 = 36$$

$$4i_1 - 7i_2 + 3i_3 - 2i_x = 0 \Rightarrow 4i_1 - 7i_2 + 3i_3 - 2i_3 = 0 \quad 4i_1 - 7i_2 = -3 \quad \text{2. denklem}$$

$$\begin{bmatrix} 7 & -4 & 36 \\ 4 & -7 & -3 \end{bmatrix} \sim \begin{bmatrix} 11 & -11 & 33 \\ 4 & -7 & -3 \end{bmatrix} \sim \begin{bmatrix} 1 & -1 & 3 \\ 4 & -7 & -3 \end{bmatrix} \sim \begin{bmatrix} 1 & -1 & 3 \\ 0 & -3 & -15 \end{bmatrix}$$

$$\sim \begin{bmatrix} 1 & -1 & 3 \\ 0 & 1 & 5 \end{bmatrix} \sim \begin{bmatrix} 1 & 0 & 8 \\ 0 & 1 & 5 \end{bmatrix} \quad i_1 = 8A, i_2 = 5A$$

$$V_2 = 2i_x = 2i_3 = 6V \quad V_1 = 4(i_1 - i_2) = 4(8 - 5) = 12V$$

Mesh Analizi (KVL) ile akımları hesapla.

$$i_1 + i_3 = 6 \Rightarrow i_3 = 6 - i_1$$

$$12 + 4i_1 - 5i_3 = 0$$

$$12 + 4i_1 - 5(6 - i_1) = 0$$

$$9i_1 = 18 \Rightarrow i_1 = 2A$$

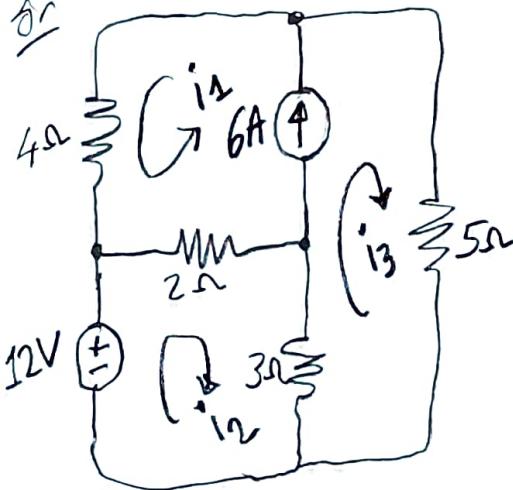
$$i_3 = 6 - i_1 = 4A$$

$$12 - 2i_1 - 5i_2 + 3i_3 = 0$$

$$12 - 4 - 5i_2 + 12 = 0$$

$$5i_2 = 20$$

$$i_2 = 4A$$



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Node Analizi (KCL) kullanarak  
 $V_1, V_2, V_3$  voltajlarının hesapla.

$$V_3 = 4i_x$$

$$2i_x = \frac{V_2 - 5}{2} + \frac{V_2 - V_3}{3}, 6 \text{ ile çarp}$$

$$12i_x = 3(V_2 - 5) + 2(V_2 - V_3)$$

$$3V_3 = 3V_2 - 15 + 2V_2 - 2V_3 \Rightarrow V_3 = V_2 - 3$$

$$\frac{V_1 - 45}{3} + \frac{V_1 - V_3 - 3}{3} + \frac{V_2 - 5}{2} + \frac{V_2 - V_3}{3} = 0, 6 \text{ ile çarp}$$

$$2V_1 - 90 + 2V_1 - 2V_3 - 6 + 3V_2 - 15 + 2V_2 - 2V_3 = 0 \quad \text{1. denklem}$$

$$4V_1 + 5V_2 - 4V_3 = 111 \Rightarrow 4V_1 + 5V_2 - 4(V_2 - 3) = 0 \Rightarrow 4V_1 + V_2 = 99$$

$$\frac{V_3 + 3 - V_1}{3} + \frac{V_3 - V_2}{3} + \frac{V_3}{4} = 0, 12 \text{ ile çarp.} \quad \text{2. denklem}$$

$$4V_3 + 12 - 4V_1 + 4V_3 - 4V_2 + 3V_3 = 0$$

$$4V_1 + 4V_2 - 11V_3 = 12 \Rightarrow 4V_1 + 4V_2 - 11(V_2 - 3) = 12 \Rightarrow 7V_2 - 4V_1 = 21$$

$$1. \text{ denklem } \text{ ile } 2. \text{ denklemi toplayarak } 8V_2 = 120 \quad V_2 = 15V$$

$$V_3 = V_2 - 3 = 12V, V_1 = \frac{99 - V_2}{4} = \frac{99 - 15}{4} = \frac{84}{4} = 21V$$


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Mesh Analizi (KVL) ile yapsayız

$V_3 = 4i_x \Rightarrow i_x = \frac{V_3}{4} = i_3$

$2i_x = i_1 + i_2 = 2i_3$

$45 - 3i_1 + 3i_2 - 3 - 4i_3 = 0$

$45 - 3i_1 + 3i_2 - 3 - 2(i_1 + i_3) = 0$

$5i_1 - i_2 = 42 \quad \text{1. denklem}$

$5 + 2i_3 - 3i_2 - 9i_3 = 0$

$10 + 4i_1 - 6i_2 - 9(i_1 + i_2) = 0$

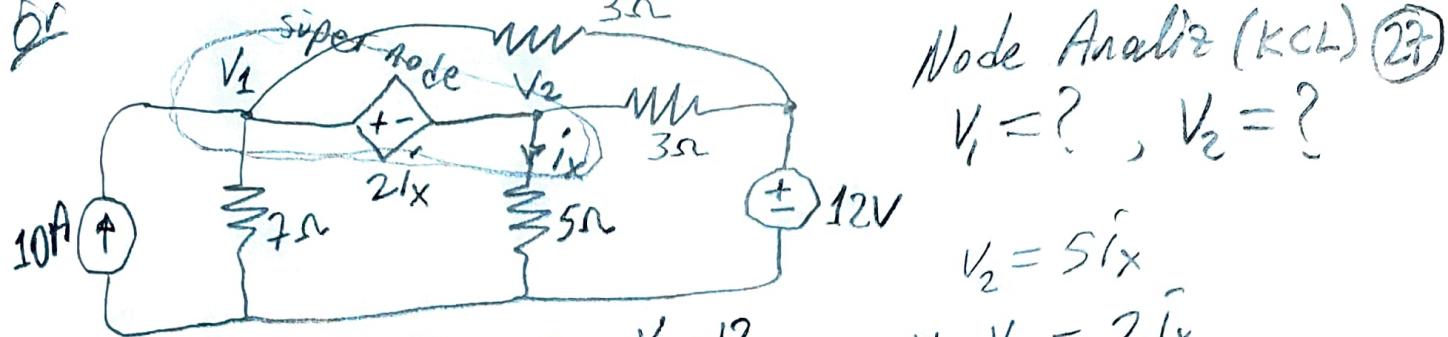
$i_1 + 3i_2 = 2 \quad \text{2. denklem}$

$$\begin{bmatrix} 5 & -1 & 42 \\ 1 & 3 & 2 \end{bmatrix} \sim \begin{bmatrix} 1 & 0 & 8 \\ 0 & 1 & -2 \end{bmatrix}$$

$$i_1 = 8A, i_2 = -2A \quad V_2 = 5 + 2(i_1 - i_3) = 5 + 2(8 - 3) = 15V$$

$$i_3 = i_1 + i_2 = 3A \quad V_3 = 4i_3 = 12V$$

$$V_1 = 45 - 3i_1 = 45 - 3 \times 8 = 21V$$



Node Analiz (KCL) 27

$$V_1 = ? , V_2 = ?$$

$$V_2 = 5ix$$

$$V_1 - V_2 = 2ix$$

$$V_1 = V_2 + 2ix = 5ix + 2ix$$

$$V_1 = 7ix$$

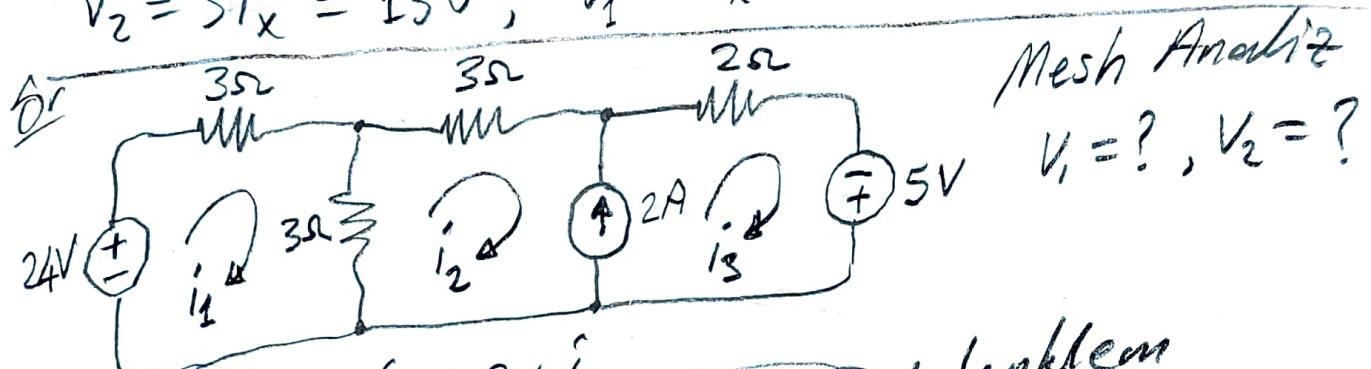
$$-10 + \frac{V_1}{7} + \frac{V_1 - 12}{3} + ix + \frac{V_2 - 12}{3} = 0$$

$$-10 + \frac{7ix}{7} + \frac{7ix - 12}{3} + ix + \frac{5ix - 12}{3} = 0$$

$$-10 + ix + \frac{7ix}{3} - 4 + ix + \frac{5ix}{3} - 4 = 0$$

$$(1 + \frac{7}{3} + 1 + \frac{5}{3})ix = 10 + 4 + 4 \Rightarrow 6ix = 18 \Rightarrow ix = 3A$$

$$V_2 = 5ix = 15V , V_1 = 7ix = 21V$$



Mesh Analiz

$$V_1 = ? , V_2 = ?$$

$$i_3 - i_2 = 2 \Rightarrow i_3 = 2 + i_2 \quad \text{1. denklem}$$

$$24 - 6i_1 + 3i_2 = 0 \Rightarrow 2i_1 - i_2 = 8$$

$$24 - 3i_1 - 3i_2 - 2i_3 + 5 = 0$$

$$24 - 3i_1 - 3i_2 - 2i_3 + 5 = 0 \Rightarrow 3i_1 + 3i_2 + 2(2 + i_2) = 29 \quad \text{2. denklem}$$

$$3i_1 + 3i_2 + 2i_3 = 29 \Rightarrow 3i_1 + 5i_2 = 25$$

$$\begin{bmatrix} 2 & -1 & 8 \\ 3 & 5 & 25 \end{bmatrix} \sim \begin{bmatrix} 2 & -1 & 8 \\ 1 & 6 & 17 \end{bmatrix} \sim \begin{bmatrix} 0 & -13 & -26 \\ 1 & 6 & 17 \end{bmatrix} \sim \begin{bmatrix} 1 & 6 & 17 \\ 0 & 1 & 2 \end{bmatrix}$$

$$\sim \begin{bmatrix} 1 & 0 & 5 \\ 0 & 1 & 2 \end{bmatrix} \quad i_1 = 5A \quad i_2 = 2A \quad i_3 = 2 + i_2 = 4A$$

$$V_1 = 24 - 3i_1$$

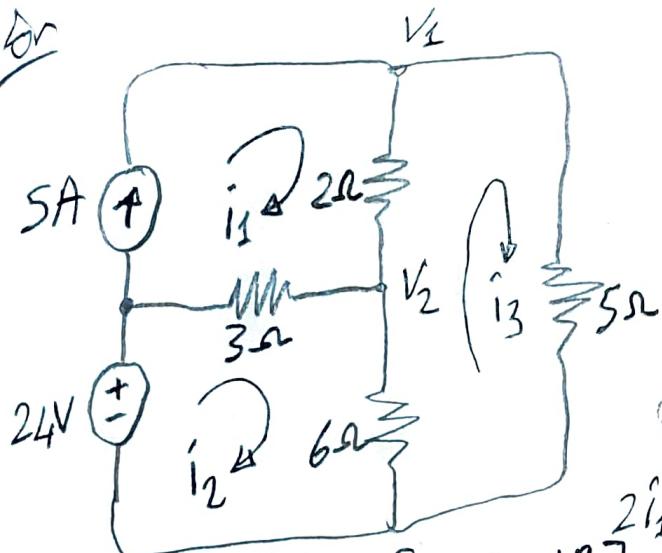
$$= 24V - 3\Omega \times 5A$$

$$= 24V - 15V = 9V$$

$$V_2 = V_1 - 3i_2$$

$$= 8V - 3\Omega \times 2A$$

$$= 8V - 6A = 3V$$



Mesh Analizi (KVL)

$$V_1 = ? \quad V_2 = ?$$

$$i_1 = 5A$$

$$24 + 3i_1 - 9i_2 + 6i_3 = 0$$

$$9i_2 - 6i_3 = 39 \quad 1. \text{ denklem}$$

$$2i_1 + 6i_2 - 13i_3 = 0 \quad 2. \text{ denklem}$$

$$6i_2 - 13i_3 = -10$$

$$\begin{bmatrix} 9 & -6 & 39 \\ 6 & -13 & -10 \end{bmatrix} \sim \begin{bmatrix} 3 & 7 & 49 \\ 6 & -13 & -10 \end{bmatrix}$$

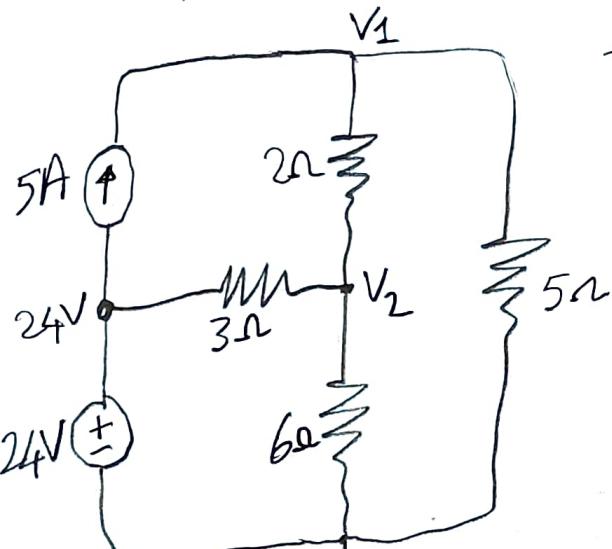
$$\sim \begin{bmatrix} 3 & 7 & 49 \\ 0 & -27 & -108 \end{bmatrix} \sim \begin{bmatrix} 3 & 7 & 49 \\ 0 & 1 & 4 \end{bmatrix}$$

$$i_2 = 7A, i_3 = 4A$$

$$V_1 = 5i_3 = 5\Omega \times 4A = 20V$$

$$V_2 = 6(i_2 - i_3) = 6\Omega(7A - 4A) \\ = 6\Omega \times 3A = 18V$$

Node Analizi (KCL) kullanılsa iðli.



$$-5 + \frac{V_1 - V_2}{2} + \frac{V_1}{5} = 0, \text{ 10. tür şart}$$

$$7V_1 - 5V_2 = 50 \quad 1. \text{ denklem}$$

$$\frac{V_2 - V_1}{2} + \frac{V_2 - 24}{3} + \frac{V_2}{6} = 0, \text{ 6. tür şart}$$

$$3V_2 - 3V_1 + 2V_2 - 48 + V_2 = 0$$

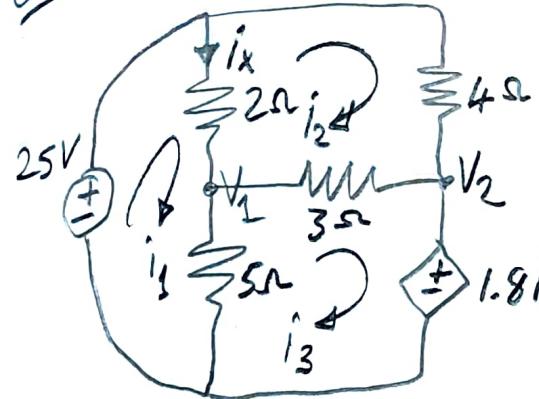
$$6V_2 - 3V_1 = 48 \Rightarrow 2V_2 - V_1 = 16 \quad 2. \text{ denklem}$$

$$\begin{bmatrix} 7 & -5 & 50 \\ -1 & 2 & 16 \end{bmatrix} \sim \begin{bmatrix} 6 & -3 & 66 \\ -1 & 2 & 16 \end{bmatrix} \sim \begin{bmatrix} 2 & -1 & 22 \\ -1 & 2 & 16 \end{bmatrix}$$

$$\sim \begin{bmatrix} 0 & 3 & 54 \\ -1 & 2 & 16 \end{bmatrix} \sim \begin{bmatrix} 1 & -2 & -16 \\ 0 & 1 & 18 \end{bmatrix} \sim \begin{bmatrix} 1 & 0 & 20 \\ 0 & 1 & 18 \end{bmatrix}$$

$$V_1 = 20V, V_2 = 18V$$

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## Mesh Analizi (KVL)

$$V_1 = ? \quad V_2 = ?$$

$$i_x = i_1 - i_2, \quad V_2 = 1.8i_x$$

$$25 - 7i_1 + 2i_2 + 5i_3 = 0$$

$$7i_1 - 2i_2 - 5i_3 = 25 \quad 1. \text{ denklem}$$

$$2i_1 - 9i_2 + 3i_3 = 0 \quad 2. \text{ denklem}$$

$$5i_1 + 3i_2 - 8i_3 - 1.8i_x = 0$$

$$5i_1 + 3i_2 - 8i_3 - 1.8(i_1 - i_2) = 0$$

5 tane eşitlik

$$25i_1 + 15i_2 - 40i_3 - 9i_1 + 9i_2 = 0$$

$$\begin{bmatrix} 7 & -2 & -5 & 25 \\ 2 & -9 & 3 & 0 \\ 2 & 3 & -5 & 0 \end{bmatrix} \sim \begin{bmatrix} 1 & 0 & 0 & 9 \\ 0 & 1 & 0 & 4 \\ 0 & 0 & 1 & 6 \end{bmatrix} \quad i_1 = 9A, i_2 = 4A, i_3 = 6A$$

$$V_1 = 5(i_1 - i_3) = 5 \times 3A = 15V$$

$$V_2 = 1.8i_x = 1.8(i_1 - i_2)$$

$$= 1.8 \times (9A - 4A) = 9V$$

## Node Analizi (KCL)

$$V_1 = ? \quad V_2 = ?$$

$$V_1 = 25 - 2i_x, \quad V_2 = 1.8i_x$$

$$-i_x + \frac{V_1}{5} + \frac{V_1 - V_2}{3} = 0, \quad 15 \text{ tane eşitlik.}$$

$$-15i_x + 3V_1 + 5V_1 - 5V_2 = 0$$

$$-15i_x + 8V_1 - 5V_2 = 0$$

$$-15i_x + 8(25 - 2i_x) - 5 \times 1.8i_x = 0$$

$$40i_x = 200 \Rightarrow i_x = 5A$$

$$V_1 = 25 - 2i_x$$

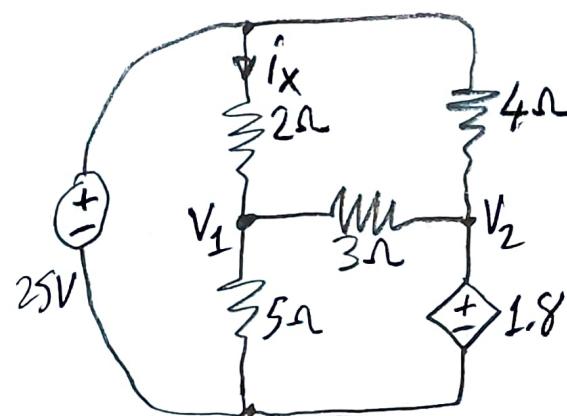
$$= 25V - 2\Omega \times 5A$$

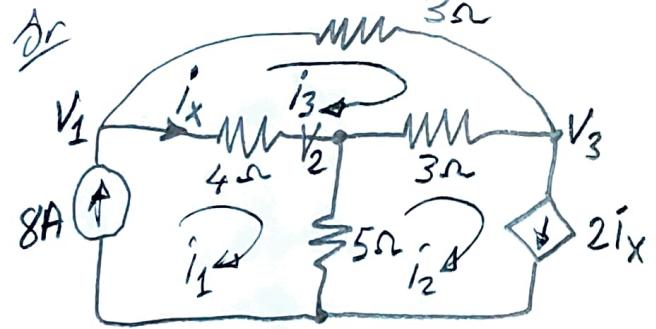
$$= 25V - 10V$$

$$= 15V$$

$$V_2 = 1.8i_x = 1.8\Omega \times 5A$$

$$= 9V$$





Mesh Analyse (KVL)

$$V_1 = ? \quad V_2 = ? \quad V_3 = ?$$

$$i_1 = 8A, \quad i_2 = 2i_x$$

$$i_x = i_1 - i_3 \Rightarrow i_3 = i_1 - i_x = 8 - i_x$$

$$4i_1 + 3i_2 - 10i_3 = 0$$

$$4 \times 8 + 3 \times 2i_x - 10(8 - i_x) = 0$$

$$32 + 6i_x - 80 + 10i_x = 0$$

$$16i_x = 48 \Rightarrow i_x = 3A$$

$$i_2 = 2i_x = 2 \times 3A = 6A$$

$$i_3 = 8 - i_x = 8A - 3A = 5A$$

$$V_2 = 5(i_1 - i_2) = 5\Omega(8A - 6A)$$

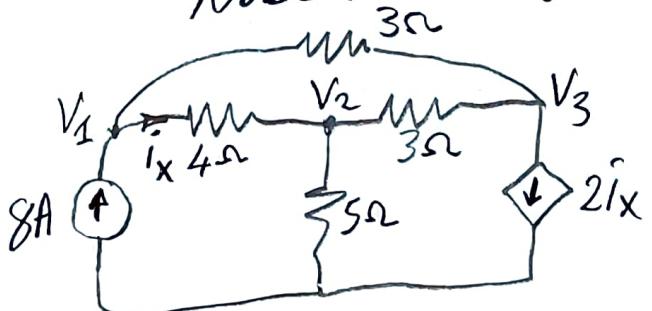
$$= 5\Omega \times 2A = 10V$$

$$i_x = i_1 - i_3 = 8A - 5A = 3A$$

$$V_1 = V_2 + 4i_x = 10V + 4\Omega \times 3A = 22V$$

$$V_3 = V_1 - 3i_3 = 22V - 3\Omega \times 5A = 7V$$

Node Analyse (KCL) kantlan saydih.



$$i_x = \frac{V_1 - V_2}{4}$$

$$-8 + \frac{V_1 - V_2}{4} + \frac{V_1 - V_3}{3} = 0, \text{ 12. ie 3. gap}$$

$$-96 + 3V_1 - 3V_2 + 4V_1 - 4V_3 = 0 \quad \text{1. denklem}$$

$$7V_1 - 3V_2 - 4V_3 = 96$$

$$\frac{V_2 - V_1}{4} + \frac{V_2}{5} + \frac{V_2 - V_3}{3} = 0, \text{ 60. ie 5. gap}$$

$$15V_2 - 15V_1 + 12V_2 + 20V_2 - 20V_3 = 0$$

$$\frac{V_3 - V_1}{3} + \frac{V_3 - V_2}{3} + 2i_x = 0 \quad \text{12. ie 3. gap} \Rightarrow 4V_3 - 4V_1 + 4V_3 - 4V_2 + 6V_1 - 6V_2 = 0$$

$$\frac{V_3 - V_1}{3} + \frac{V_3 - V_2}{3} + 2 \frac{V_1 - V_2}{4} = 0$$

$$V_1 - 5V_2 + 4V_3 = 0 \quad \text{3. denklem}$$

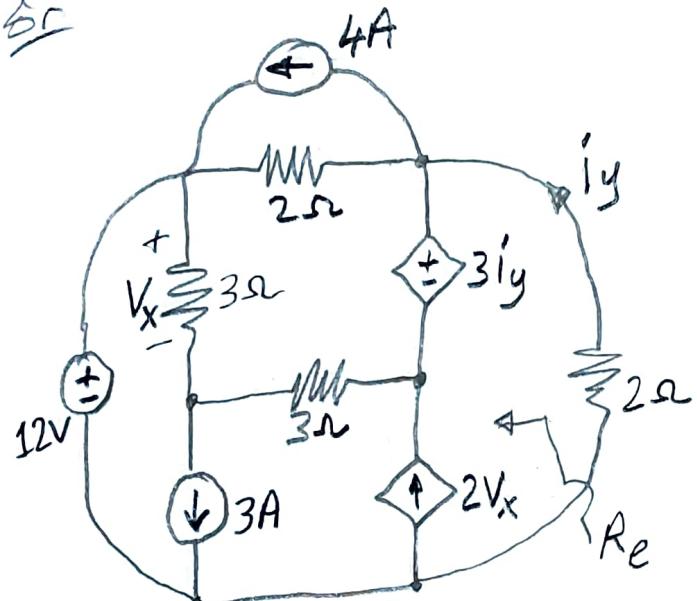
$$\begin{bmatrix} 7 & -3 & -4 & 96 \\ 15 & -47 & 20 & 0 \\ 1 & -5 & 4 & 0 \end{bmatrix} \sim \begin{bmatrix} 0 & 32 & -32 & 96 \\ 0 & 28 & -40 & 0 \\ 1 & -5 & 4 & 0 \end{bmatrix} \sim \begin{bmatrix} 1 & -5 & 4 & 0 \\ 0 & 1 & -1 & 3 \\ 0 & 7 & -10 & 0 \end{bmatrix}$$

$$\sim \begin{bmatrix} 1 & 0 & -1 & 15 \\ 0 & 1 & -1 & 3 \\ 0 & 0 & 1 & 7 \end{bmatrix} \sim \begin{bmatrix} 1 & 0 & -1 & 15 \\ 0 & 1 & -1 & 3 \\ 0 & 0 & 1 & 7 \end{bmatrix} \sim \begin{bmatrix} 1 & 0 & 0 & 22 \\ 0 & 1 & 0 & 10 \\ 0 & 0 & 1 & 7 \end{bmatrix} \rightarrow V_1 = 22V$$

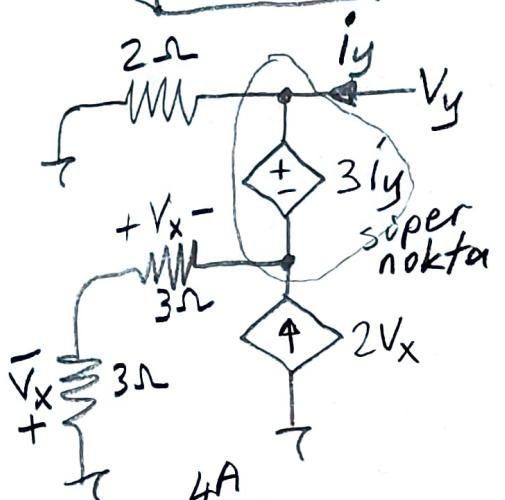
$$V_2 = 10V$$

$$V_3 = 7V$$

(31)



$R_e = ?$   
 Aşik derre kullanarak  $V_e = ?$   
 Kısa derre kullanarak  $I_e = ?$   
 Thevenin eşdeğeriini siziniz.  
 Norton eşdeğeriini siziniz.  
 $i_y$  akımını bulunuz.



$$\frac{V_y}{2} - i_y - 2V_x - \frac{V_x}{3} = 0, \text{ 6 tane şart}$$

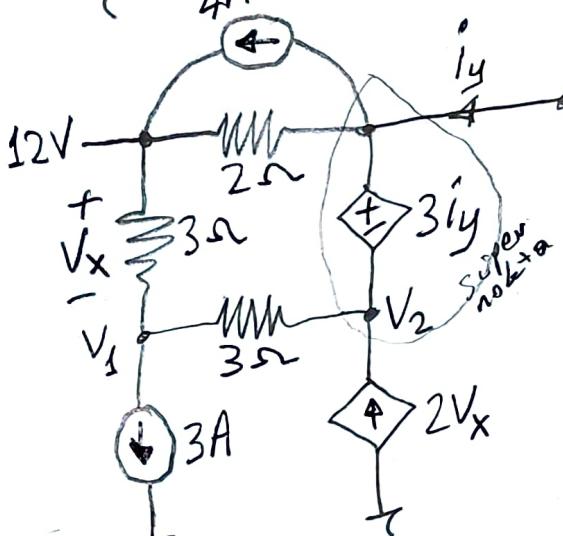
$$3V_y - 6i_y - 14V_x = 0 \quad 1. \text{ denklem}$$

$$V_y - 3i_y + 2V_x = 0 \quad 2. \text{ denklem}$$


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$$V_y = 18V_x, i_y = \frac{20}{3}V_x$$

$$R_e = \frac{V_y}{i_y} = \frac{18V_x}{\frac{20}{3}V_x} = 2.7\Omega$$



$$V_1 = 12 - V_x$$

$$i_y = 0 \Rightarrow V_2 = V_e$$

$$3 - \frac{V_x}{3} + \frac{V_1 - V_2}{3} = 0$$

$$9 - V_x + V_1 - V_2 = 0$$

$$9 - V_x + 12 - V_x - V_e = 0$$

$$2V_x + V_e = 21 \quad 1. \text{ denklem}$$

$$4 + \frac{V_e - 12}{2} - 2V_x + \frac{V_2 - V_1}{3} = 0$$

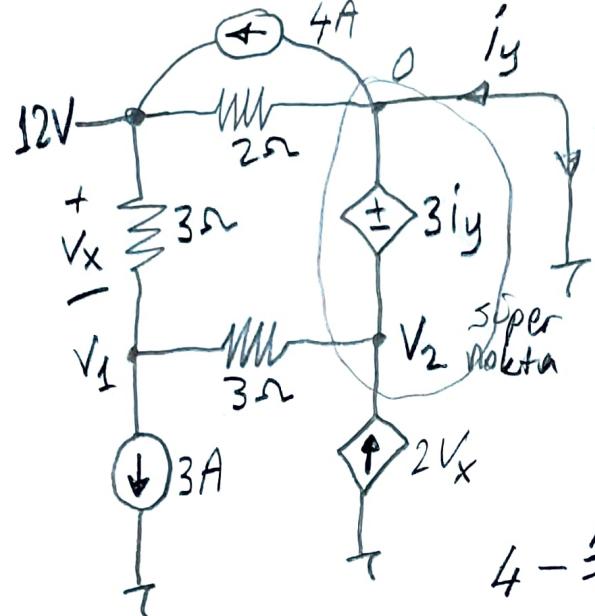
$$24 + 3V_e - 36 - 12V_x + 2V_2 - 2V_1 = 0$$

$$3V_e - 12 - 12V_x + 2V_e - 2(12 - V_x) = 0 \Rightarrow 5V_e - 10V_x = 36$$

$$1. \text{ denklemden } V_x = \frac{21 - V_e}{2} \text{ get.}$$

$$2. \text{ denklemde yerine koy. } 5V_e - 10 \cdot \frac{21 - V_e}{2} = 36 \Rightarrow V_e = 14.1V$$

2 denklem



$$V_1 = 12 - V_x, V_2 = -3iy$$

$$3 - \frac{V_x}{3} + \frac{V_1 - V_2}{3} = 0$$

$$9 - V_x + V_1 - V_2 = 0$$

$$9 - V_x + 12 - V_x + 3iy = 0$$

$$2V_x - 3iy = 21 \quad \text{1. Denklem}$$

$$4 - \frac{12}{2} - iy - 2V_x + \frac{V_2 - V_1}{3} = 0$$

$$-2 - iy - 2V_x + \frac{V_2 - V_1}{3} = 0 \quad \text{3. ile 4. soru}$$

$$-6 - 3iy - 6V_x + V_2 - V_1 = 0$$

$$-6 - 3iy - 6V_x - 3iy - 12 + V_x = 0 \Rightarrow 5V_x + 6iy = -18 \quad \text{2. Denklem}$$

$$\text{1. denklemden } V_x = \frac{21 + 3iy}{2} \text{ gek.}$$

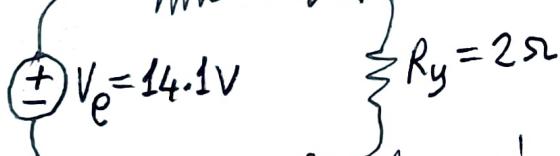
2. denklemde yerine koy.

$$5 \frac{21 + 3iy}{2} + 6iy = -18 \Rightarrow iy = -\frac{47}{9} A$$

$$Re = \frac{2}{2.7\Omega}$$

$$iy$$

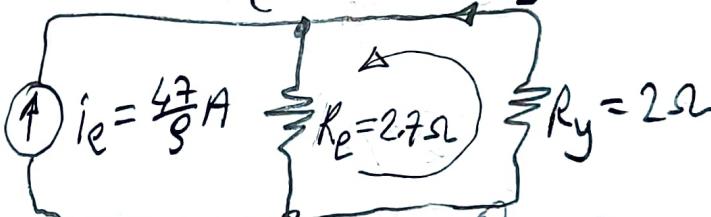
$$ie = -iy = \frac{47}{9} A$$



Thevenin Esdeger Devresi

$$iy = -\frac{Ve}{Re + Ry} = \frac{-14.1V}{2.7\Omega + 2\Omega}$$

$$= -\frac{14.1V}{4.7\Omega} = -3A$$



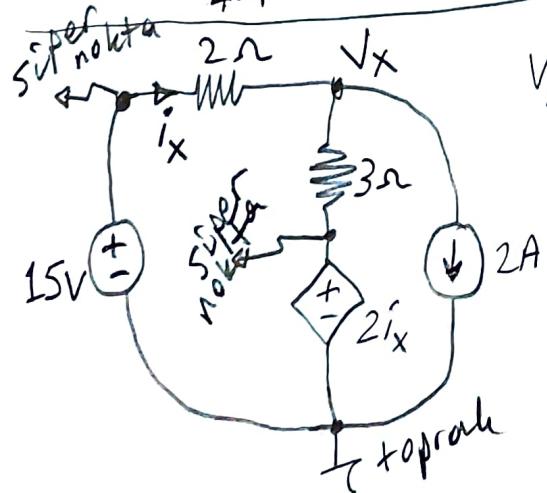
Norton Esdeger Devre

$$Ry iy + Re(ie + iy) = 0$$

$$(Re + Ry)iy + Reie = 0$$

$$iy = -\frac{Reie}{Re + Ry} = -\frac{2.7}{2.7 + 2} \frac{47}{9} A$$

$$= -3A$$



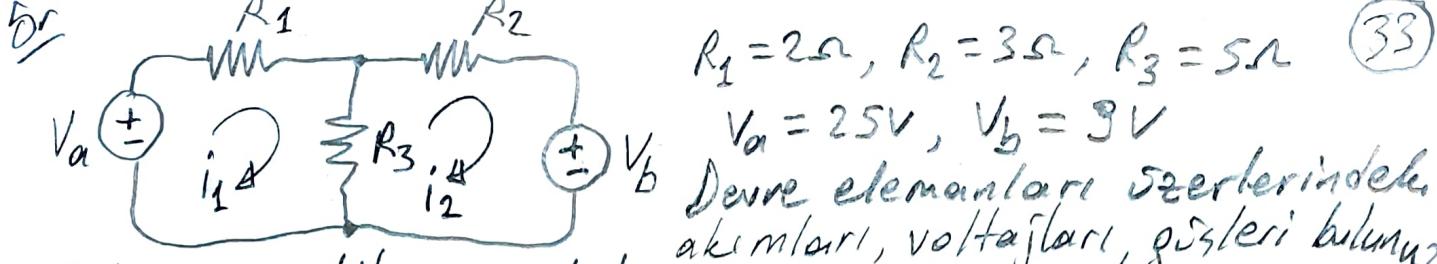
$$V_x = 15 - 2ix$$

$$2 + \frac{V_x - 2ix}{3} - ix = 0$$

$$6 + V_x - 2ix - 3ix = 0$$

$$V_x - 5ix + 6 = 0$$

$$15 - 2ix - 5ix + 6 = 0 \Rightarrow ix = 3A$$



$$R_1 = 2\Omega, R_2 = 3\Omega, R_3 = 5\Omega \quad (33)$$

$$V_a = 25V, V_b = 9V$$

Devre elementlerin s̄zerlerindeki akımları, voltagları, ḡslerini bulunuz.

Toplam üretilen ve tüketilen gücü bulunuz.

$$V_a - (R_1 + R_3)i_1 + R_3i_2 = 0 \Rightarrow 7i_1 - 5i_2 = 25 \quad 1. \text{ denklem}$$

$$R_3i_1 - (R_2 + R_3)i_2 - V_b = 0 \Rightarrow 5i_1 - 8i_2 = 9 \quad 2. \text{ denklem}$$

1. denklemden  $i_2 = \frac{7}{5}i_1 - 5$  get.

2. denklemde yerine koy.  $i_1 = 5A, i_2 = \frac{7}{5}i_1 - 5 = 2A$   
 $5i_1 - 8\left(\frac{7}{5}i_1 - 5\right) = 9 \Rightarrow i_1 = 5A, i_2 = \frac{7}{5}i_1 - 5 = 2A$   
 $i_3 = i_1 - i_2 = 5A - 2A = 3A$

$$V_1 = R_1 i_1 = 2\Omega \times 5A = 10V \quad P_1 = V_1 i_1 = 10V \times 5A = 50W$$

$$V_2 = R_2 i_2 = 3\Omega \times 2A = 6V \quad P_2 = V_2 i_2 = 6V \times 2A = 12W$$

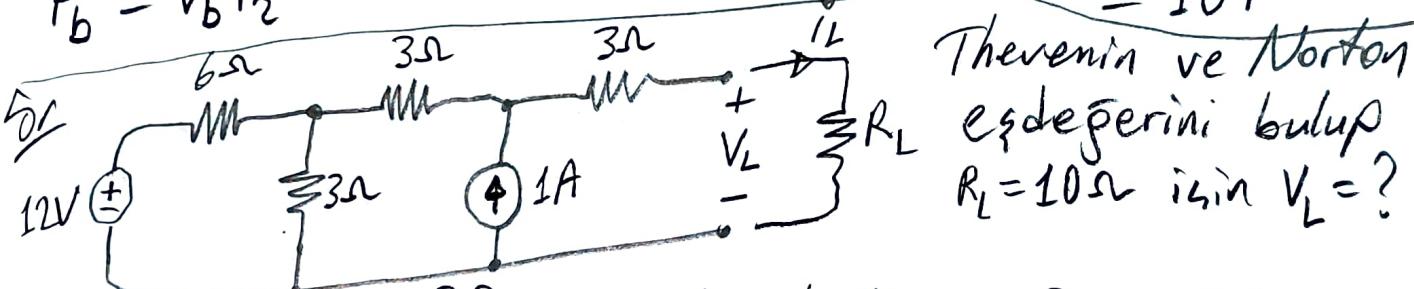
$$V_3 = R_3 i_3 = 5\Omega \times 3A = 15V \quad P_3 = V_3 i_3 = 15V \times 3A = 45W$$

$$P_{\text{topuk}} = P_1 + P_2 + P_3 = 50W + 12W + 45W = 107W$$

$$P_a = V_a i_1 = 25V \times 5A = 125W \quad \begin{matrix} \text{Üretici} \\ \text{Tüketici} \end{matrix} \quad P_{\text{net}} = P_a - P_a$$

$$P_b = V_b i_2 = 9V \times 2A = 18W \quad = 125W - 18W$$

$$= 107W$$

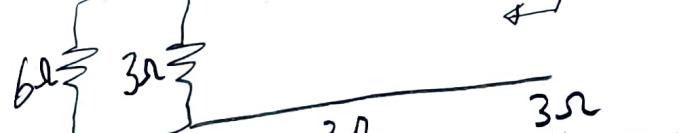


Theremin ve Norton  
egdeğerini bulup  
 $R_L = 10\Omega$  için  $V_L = ?$

$$R_e = 6\Omega // 3\Omega + 3\Omega + 3\Omega$$

$$= \frac{6\Omega \times 3\Omega}{3\Omega} + 6\Omega = 2\Omega + 6\Omega$$

$$= 8\Omega$$



$$i_2 = 1A$$

$$12 - 9i_1 - 3i_2 = 0$$

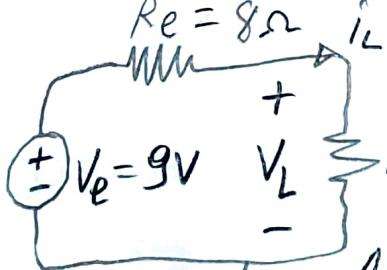
$$4 - 3i_1 - i_2 = 0$$

$$i_1 = \frac{4 - i_2}{3} = 1A$$



$$12 - 6i_1 + 3i_2 = V_e$$

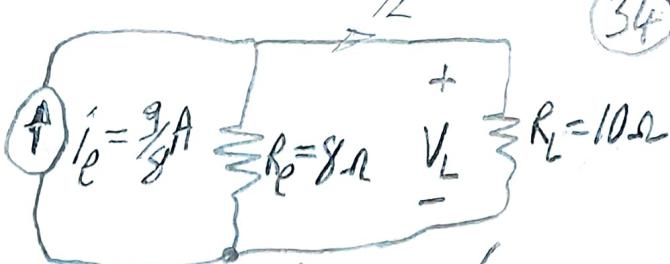
$$V_e = 12V - 6V + 3V = 9V$$



Thevenin Esdeğer Devre

$$i_L = \frac{V_e}{R_e + R_L} = \frac{9V}{8\Omega + 10\Omega} = \frac{9V}{18\Omega} = 0.5A$$

$$V_L = R_L i_L = 10\Omega \times 0.5A = 5V$$

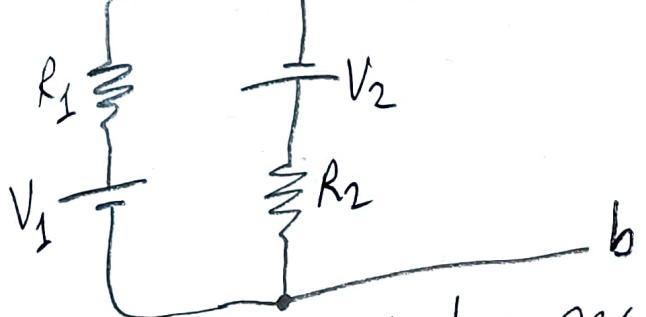


Norton esdeğer devre

$$R_L = R_3 = 3\Omega, R_2 = 6\Omega$$

$$V_1 = 15V, V_2 = 12V$$

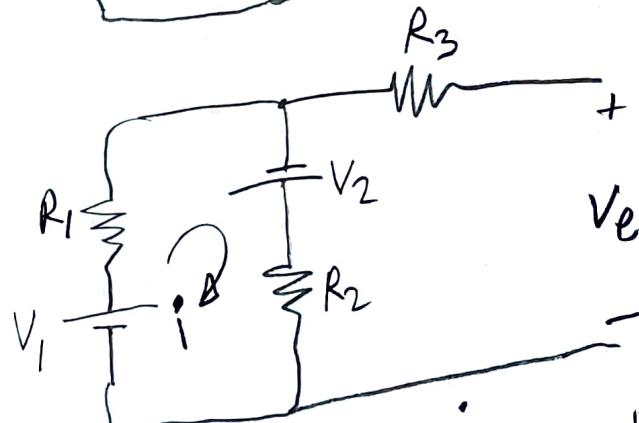
Devrenin Thevenin esdeğeri bulup uşlarına  $R_L$  direnci bağla.



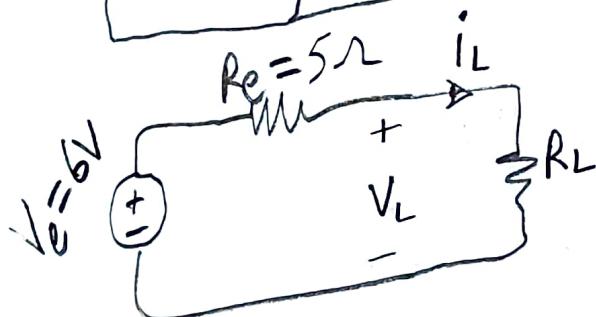
$R_L$  direnci üzerinden geçen akım  $i_L = 0.5A$  ise  
 $R_L$  ve  $V_L$  değerlerini hesapla.



$$\begin{aligned} R_e &= R_1 // R_2 + R_3 \\ &= 3\Omega // 6\Omega + 3\Omega \\ &= 2\Omega + 3\Omega = 5\Omega \end{aligned}$$



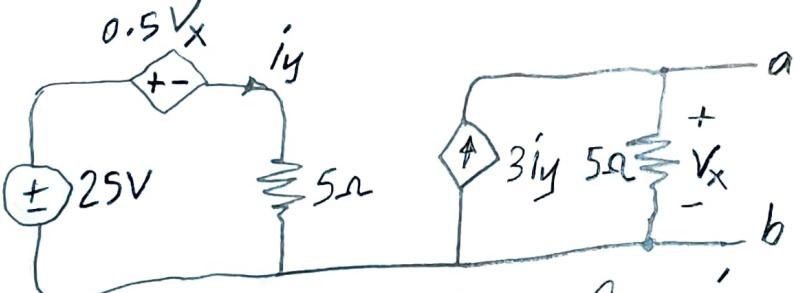
$$\begin{aligned} V_e &+ V_2 - (R_1 + R_2) i = 0 \\ i &= \frac{V_1 + V_2}{R_1 + R_2} = \frac{15V + 12V}{3\Omega + 6\Omega} \\ &= \frac{27V}{9\Omega} = 3A \end{aligned}$$



$$V_e = V_1 - R_1 i = 15V - 3\Omega \times 3A = 15V - 9V = 6V$$

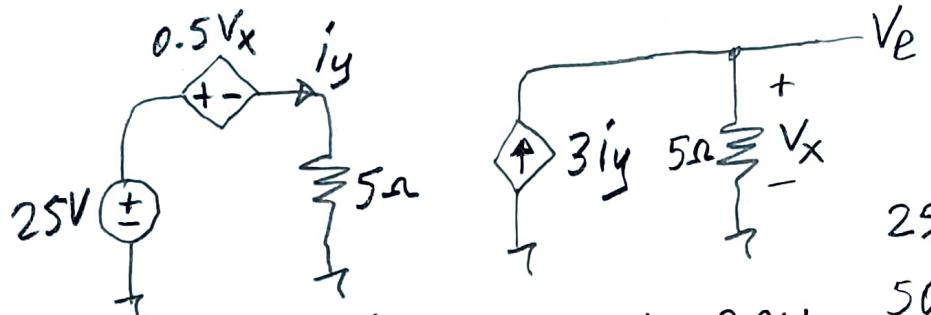
$$i_L = \frac{V_e}{R_e + R_L} \Rightarrow 0.5 = \frac{6}{5 + R_L} \Rightarrow R_L = 7\Omega$$

$$V_L = R_L i_L = 7\Omega \times 0.5A = 3.5V$$



$$V_L = i_L^2 + 4i_L + 3 \text{ için } R_L, i_L, V_L \text{ değerlerini bulunuz.}$$

Devrenin Thevenin eşdeğerini bulup uşlarına  $R_L$  direnci bağlayınız.



$$V_e = V_x = 15i_y = 15\Omega \times 2A = 30V$$

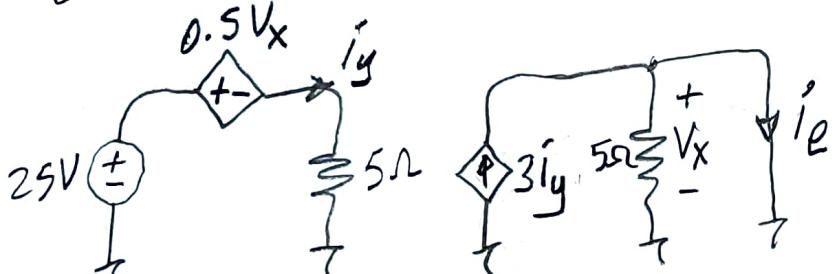
$$\begin{aligned} V_x &= 5\Omega \times 3i_y \\ &= 15i_y \end{aligned}$$

$$25 - 0.5V_x - 5i_y = 0$$

$$50 - V_x - 10i_y = 0$$

$$50 - 15i_y - 10i_y = 0$$

$$25i_y = 50 \Rightarrow i_y = 2A$$



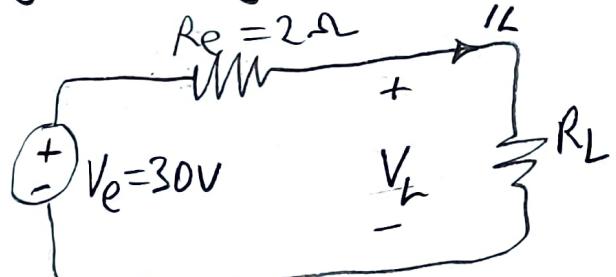
$$i_e = 3i_y = 3 \times 5A = 15A$$

$$R_e = \frac{V_e}{i_e} = \frac{30V}{15A} = 2\Omega$$

$$V_x = 0$$

$$25 - 0.5V_x - 5i_y = 0$$

$$i_y = \frac{25 - 0.5V_x}{5} = 5A$$



$$V_e - R_e i_L - V_L = 0$$

$$30 - 2i_L - i_L^2 - 4i_L - 3 = 0$$

$$i_L^2 + 6i_L - 27 = 0$$

$$(i_L - 3)(i_L + 9) = 0$$

$$i_{L_1} = 3A, i_{L_2} = -9A$$

$$i_L > 0 \text{ olmalı}$$

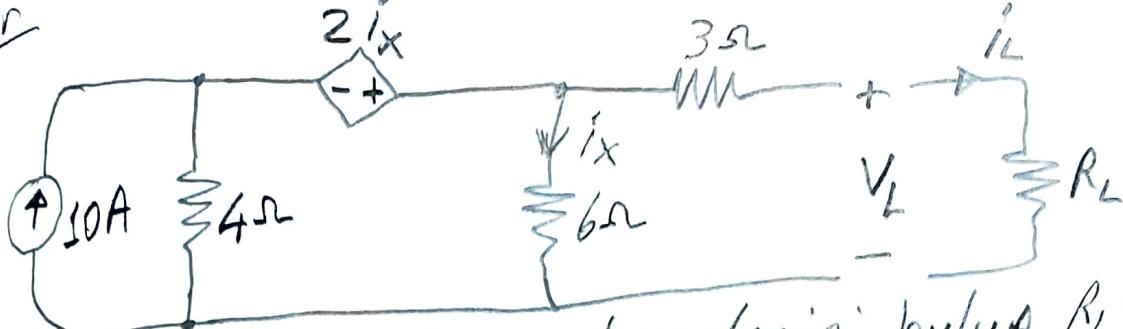
$$i_L = i_{L_1} = 3A$$

$$\begin{aligned} V_L &= i_L^2 + 4i_L + 3 \\ &= 9 + 12 + 3 \\ &= 24V \end{aligned}$$

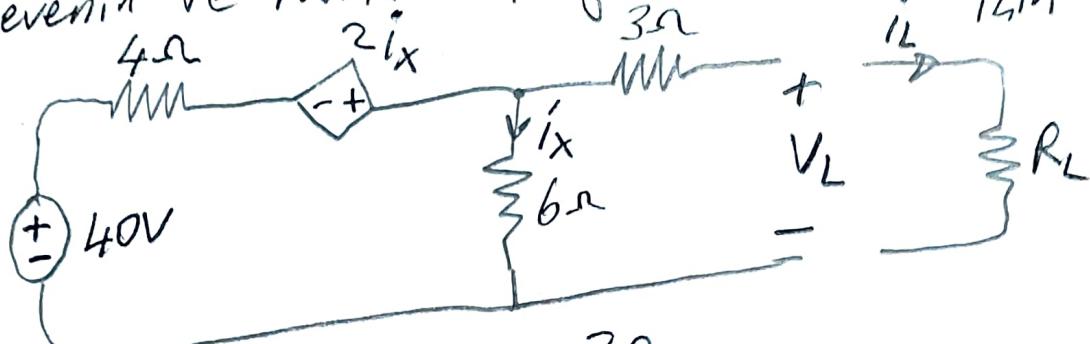
$$R_L = \frac{V_L}{i_L} = \frac{24V}{3A} = 8\Omega$$

51

36



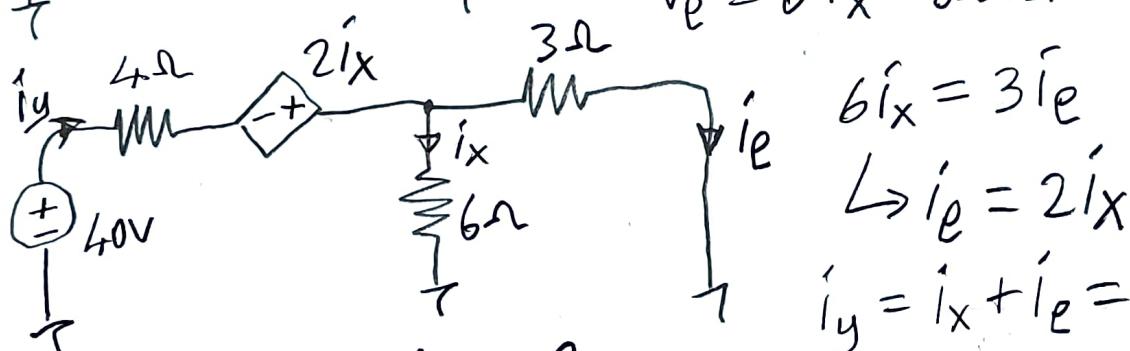
Thevenin ve Norton eşdeğerlerini bulup  $R_L = 4\Omega$  için  $V_L = ?$



$$40 - 4i_x + 2i_x - 6i_x = 0$$

$$8i_x = 40 \Rightarrow i_x = 5A$$

$$V_e = 6i_x = 6\Omega \times 5A = 30V$$



$$6i_x = 3i_e$$

$$\Rightarrow i_e = 2i_x$$

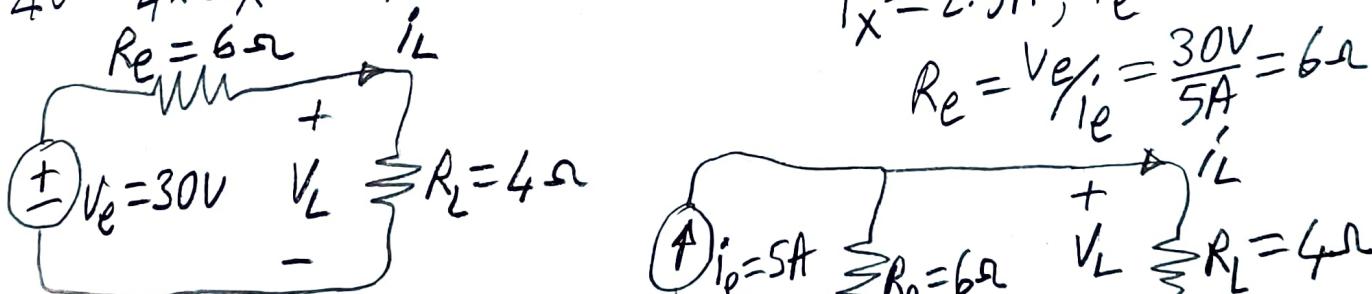
$$i_y = i_x + i_e = 3i_x$$

$$40 - 4i_y + 2i_x - 6i_x = 0$$

$$40 - 4 \times 3i_x + 2i_x - 6i_x = 0 \Rightarrow 40 - 16i_x = 0$$

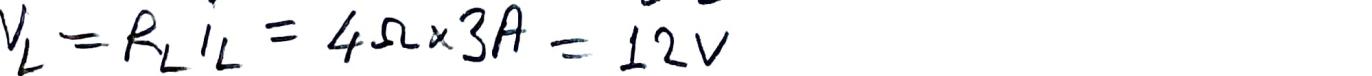
$$i_x = 2.5A, i_e = 5A$$

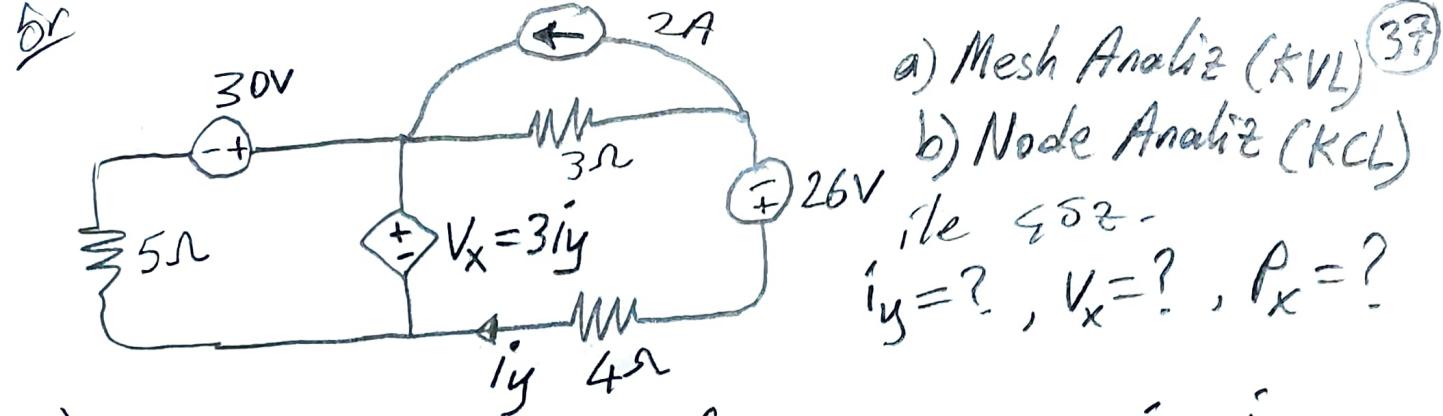
$$R_e = \frac{V_e}{i_e} = \frac{30V}{5A} = 6\Omega$$



$$i_L = \frac{V_e}{R_e + R_L} = \frac{30V}{6\Omega + 4\Omega} = \frac{30V}{10\Omega} = 3A$$

$$V_L = R_L i_L = 4\Omega \times 3A = 12V$$





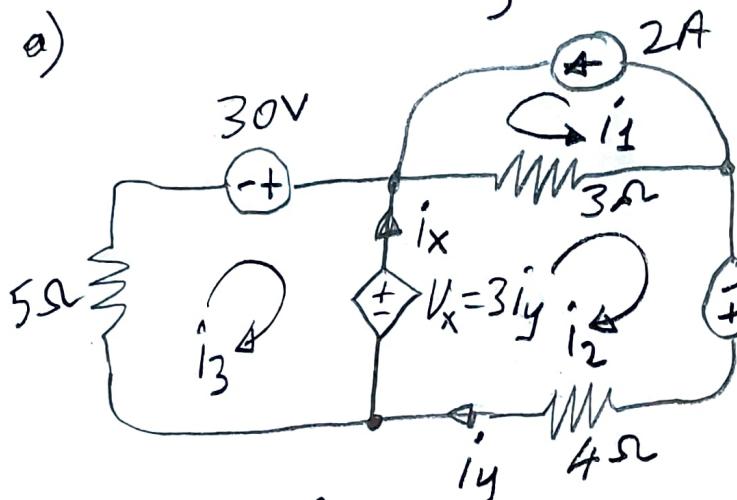
a) Mesh Analiz (KVL) 37

b) Node Analiz (KCL)

ile 5r -

$$i_y = ? , V_x = ? , P_x = ?$$

a)



$$30 - V_x - 5i_3 = 0$$

$$i_3 = \frac{30 - V_x}{5} = \frac{30 - 15}{5} A = 3A$$

$$i_1 = 2A , i_2 = i_y$$

$$V_x - 3i_1 - 7i_2 + 26 = 0$$

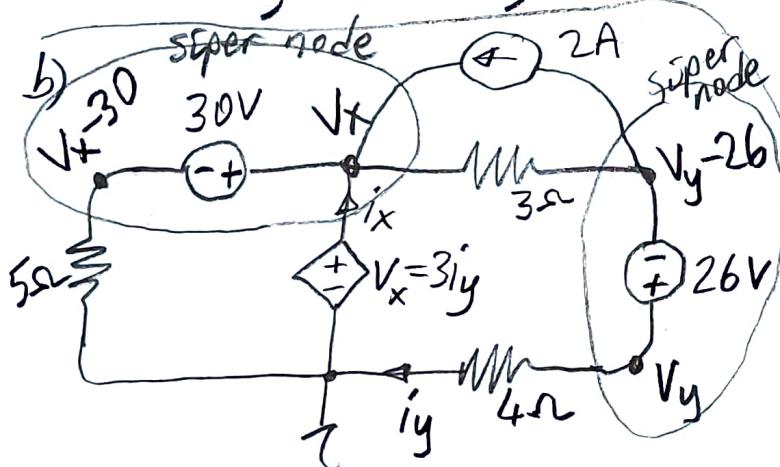
$$3i_y - 6 - 7i_y + 26 = 0$$

$$-4i_y + 20 = 0$$

$$\hookrightarrow i_y = 5A$$

$$V_x = 3i_y = 3\Omega \times 5A = 15V$$

$$i_x = i_2 - i_3 = i_y - i_3 \\ = 5A - 3A = 2A$$



$$P_x = V_x i_x = 15V \times 2A = 30W$$

İretici konumunda

$$V_x = 3i_y , V_y = 4i_y$$

$$2 + \frac{V_y - 26 - V_x}{3} + i_y = 0$$

$$6 + V_y - 26 - V_x + 3i_y = 0$$

$$-20 + 4i_y - 3i_y + 3i_y = 0$$

$$i_y = 5A$$

$$V_x = 3i_y = 3\Omega \times 5A = 15V$$

$$\frac{V_x - 30}{5} - i_x - 2 + \frac{V_x - V_y + 26}{3} = 0$$

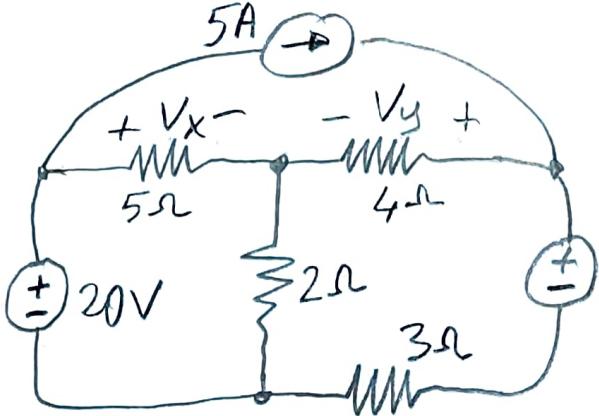
15 ile çarp

$$3V_x - 90 - 15i_x - 30 + 5V_x - 5V_y + 130 = 0$$

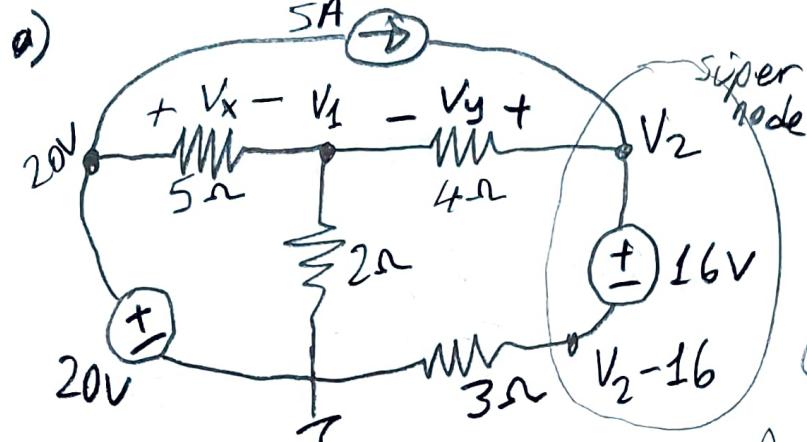
$$i_x = \frac{10 + 8V_x - 5V_y}{15} = \frac{10 + 24i_y - 20i_y}{15} = \frac{10 + 4i_y}{15} = 2A$$

$$P_x = V_x i_x = 15V \times 2A = 30W$$

İretici konumunda



- (38) a) Node Analizi (KCL)  
 b) Mesh Analizi (KVL)  
 y<sup>ü</sup>nitemini kullanarak  
 $V_x = ?$ ,  $V_y = ?$



$$\frac{V_1 - 20}{5} + \frac{V_1}{2} + \frac{V_1 - V_2}{4} = 0$$

20 ile çarp

$$4V_1 - 80 + 10V_1 + 5V_1 - 5V_2 = 0$$

$19V_1 - 5V_2 = 80$  1. denklem

Denklemler çözülmeye  
 $V_1 = 10V$ ,  $V_2 = 22V$

$$V_x = 20 - V_1 = 10V$$

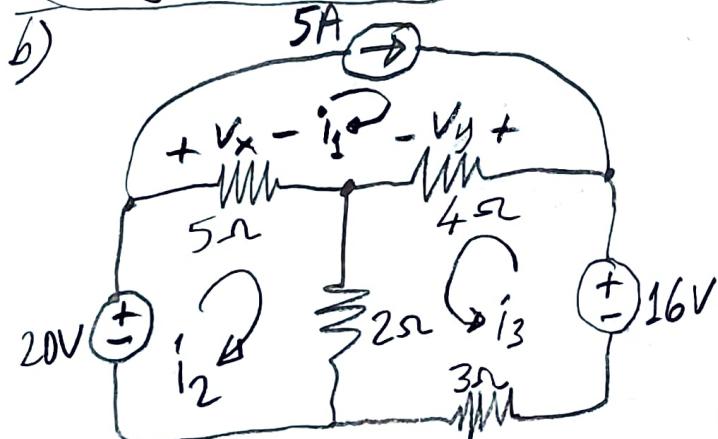
$$V_y = V_2 - V_1 = 12V$$

$$\frac{V_2 - V_1}{4} - 5 + \frac{V_2 - 16}{3} = 0$$

12 ile çarp

$$3V_2 - 3V_1 - 60 + 4V_2 - 64 = 0$$

$7V_2 - 3V_1 = 124$  2. denklem



$$i_1 = 5A$$

$$20 + 5i_1 - 7i_2 - 2i_3 = 0$$

$$7i_2 + 2i_3 = 45$$

1. denklem

$$16 - 4i_1 - 2i_2 - 9i_3 = 0$$

$$2i_2 + 9i_3 = -4$$

2. denklem

$$1. \text{ denklemde } i_3 = \frac{45 - 7i_2}{2}$$

$$2. \text{ denklemde yerine koy}$$

$$2i_2 + 9 \frac{45 - 7i_2}{2} = -4$$

$$2 \text{ ile çarp}$$

$$4i_2 + 405 - 63i_2 = -8$$

$$i_2 = \frac{413}{59} A = 7A$$

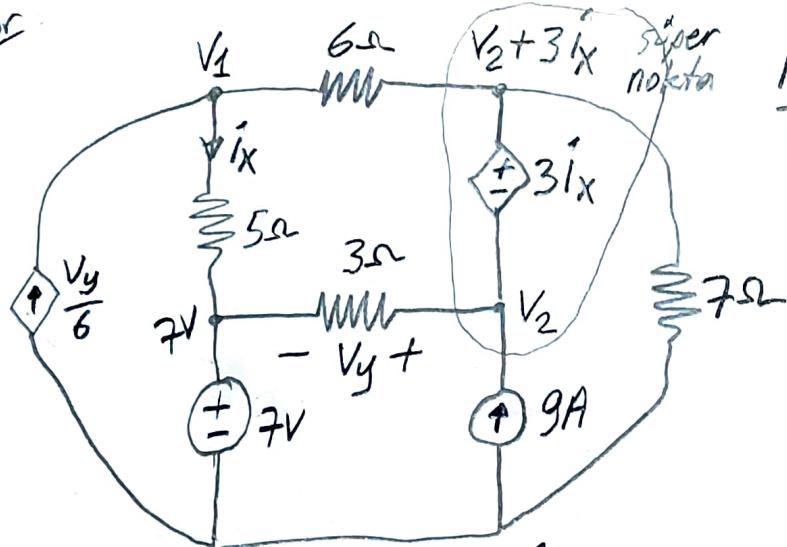
$$i_3 = \frac{45 - 7i_2}{2} = -2A$$

$$V_x = 5\Omega(i_2 - i_1) = 5\Omega \times 2A = 10V$$

$$V_y = 4\Omega(i_1 + i_3) = 4\Omega \times 3A = 12V$$

# Node Analysis (KCL)

(39)



Yönteminizi kullanarak  
 $i_x = ?$ ,  $V_y = ?$

$$V_1 = 7 + 5i_x$$

$$V_2 = 7 + V_y$$

$$-\frac{V_y}{6} + i_x + \frac{V_1 - V_2 - 3i_x}{6} = 0$$

$$-V_y + 6i_x + V_1 - V_2 - 3i_x = 0$$

$$-V_y + 6i_x + 7 + 5i_x - 7 - V_y - 3i_x = 0 \Rightarrow V_y = 4i_x$$

$$\frac{V_y}{3} - 9 + \frac{V_2 + 3i_x}{7} + \frac{V_2 + 3i_x - V_1}{6} = 0$$

$$\frac{V_y}{3} - 9 + \frac{7 + V_y + 3i_x}{7} + \frac{7 + V_y + 3i_x - 7 - 5i_x}{6} = 0$$

$$\frac{V_y}{3} + \frac{V_y + 3i_x}{7} + \frac{V_y - 2i_x}{6} = 8$$

$$\frac{4i_x}{3} + i_x + \frac{i_x}{3} = 8, \text{ 3 ile çarp}$$

$$(4+3+1)i_x = 24 \Rightarrow i_x = 3A$$

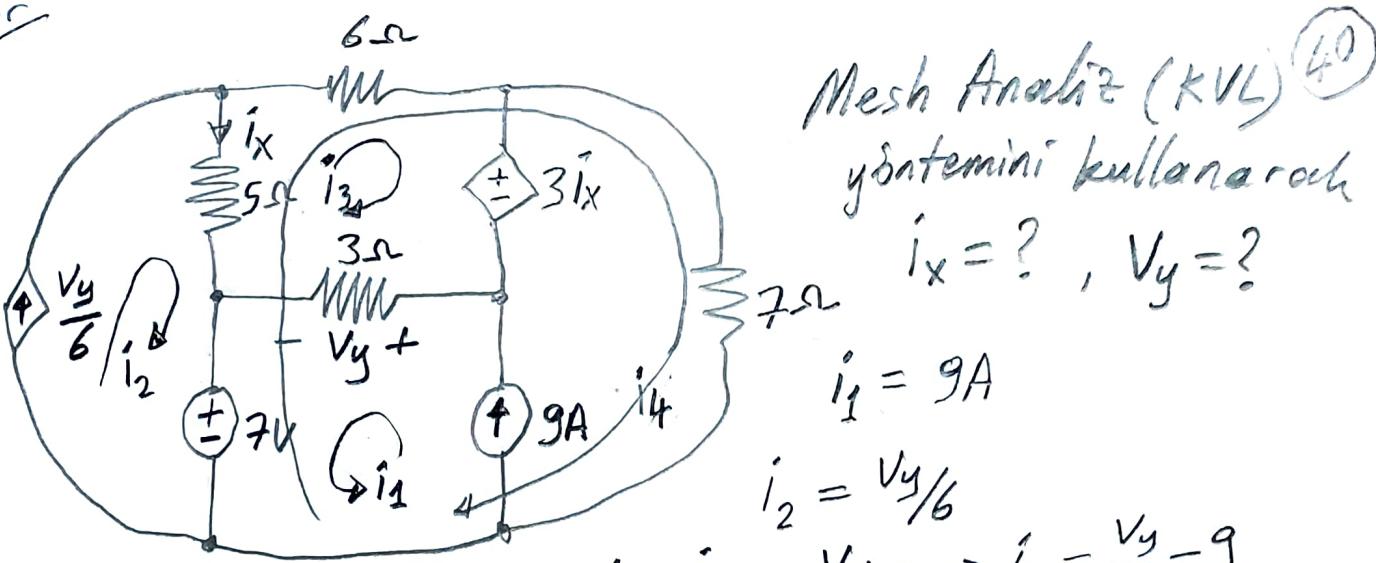
$$V_y = 4i_x = 4 \times 3A = 12V$$

5 ohm üzerinde tüketilen功率

$$P_x = R_x i_x^2 = 5 \Omega \times (3A)^2 = 45W$$

3 ohm üzerinde tüketilen功率

$$P_y = \frac{V_y^2}{R_y} = \frac{(12V)^2}{3 \Omega} = 48W$$



Mesh Analizi (KVL)  
yöntemini kullanarak  
 $i_x = ?$ ,  $V_y = ?$

$$i_1 = 9A$$

$$i_2 = \frac{V_y}{6}$$

$$i_1 + i_3 = \frac{V_y}{3} \Rightarrow i_3 = \frac{V_y}{3} - 9$$

$$i_x = i_2 - i_3 - i_4 \rightarrow i_4 = i_2 - i_3 - i_x = \frac{V_y}{6} - \left(\frac{V_y}{3} - 9\right) - i_x = 9 - i_x - \frac{V_y}{6}$$

$$5i_x - 6(i_3 + i_4) - 3i_x - V_y = 0$$

$$5i_x - 6\left(\frac{V_y}{3} - 9 + 9 - i_x - \frac{V_y}{6}\right) - 3i_x - V_y = 0$$

$$5i_x - 2V_y + 6i_x + V_y - 3i_x - V_y = 0 \Rightarrow V_y = 4i_x$$

$$7 + 5i_x - 6(i_3 + i_4) - 7i_4 = 0$$

$$7 + 5i_x - 6i_3 - 13i_4 = 0$$

$$7 + 5i_x - 6\left(\frac{V_y}{3} - 9\right) - 13\left(9 - i_x - \frac{V_y}{6}\right) = 0$$

$$7 + 5i_x - 2V_y + 54 - 117 + 13i_x + \frac{13}{6}V_y = 0$$

$$5i_x - 2 \times 4i_x + 13i_x + \frac{13}{6}4i_x = 56$$

$$10i_x + \frac{26}{3}i_x = 56 \Rightarrow i_x = 3A$$

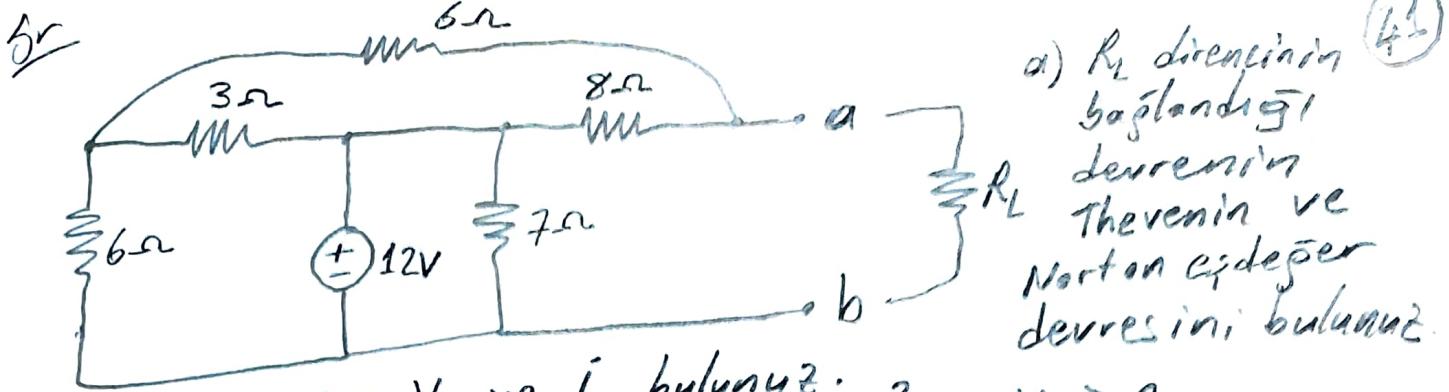
$$V_y = 4i_x = 4\Omega \times 3A = 12V$$

$5\Omega$  üzerinde tüketilen güç

$$P_x = R_x i_x^2 = 5\Omega \times (3A)^2 = 45W$$

$3\Omega$  üzerinde tüketilen güç

$$P_y = \frac{V_y^2}{R_y} = \frac{(12V)^2}{3\Omega} = 48W$$



a)  $R_L$  direncinden bağılandığı devresinin Thevenin ve Norton eylem değerlerini bulunuz.

b)  $R_L = 16\Omega$  ise  $V_L$  ve  $i_L$  bulunuz.  $V_L > 0$

c)  $R_L$  lineer değişse yani  $i_L = \begin{cases} V_L/2 & V_L > 0 \\ 0 & V_L < 0 \end{cases}$  ise  $V_L$  ve  $i_L$  bulunuz.

d)

$$17i_1 - 3i_2 = 0 \Rightarrow i_2 = \frac{17}{3}i_1$$

$$3i_1 - 9i_2 - 12 = 0$$

$$V_{oc} = 3i_1 - 9 \cdot \frac{17}{3}i_1 = 12$$

$$-48i_1 = 12 \Rightarrow i_1 = -0.25A$$

$$V_{oc} = 12V + 8\Omega \times i_1 = 12V - 8\Omega \times 0.25A = 12V - 2V = 10V = V_e$$

$$R_e = (6\Omega//3\Omega + 6\Omega)//8\Omega$$

$$= (2\Omega + 6\Omega)//8\Omega = 8\Omega//8\Omega = 4\Omega$$

$$I_e = V_e/R_e = 10V/4\Omega = 2.5A$$

$$I_e = 2.5A$$

$$R_e = 4\Omega$$

$$V_e = 10V$$

$$i_L$$

$$V_L$$

$$R_L$$

b)  $R_L$  lineer  $i_L = \frac{V_e}{R_e + R_L} = \frac{10V}{4\Omega + 16\Omega} = \frac{10V}{20\Omega} = 0.5A$ ,  $V_L = R_L i_L = 16\Omega \times 0.5A = 8V$

c)  $V_e = R_e i_L + V_L \Rightarrow 10V = 4\Omega \times 0.5V_L^2 + V_L$

$$2V_L^2 + V_L - 10 = 0$$

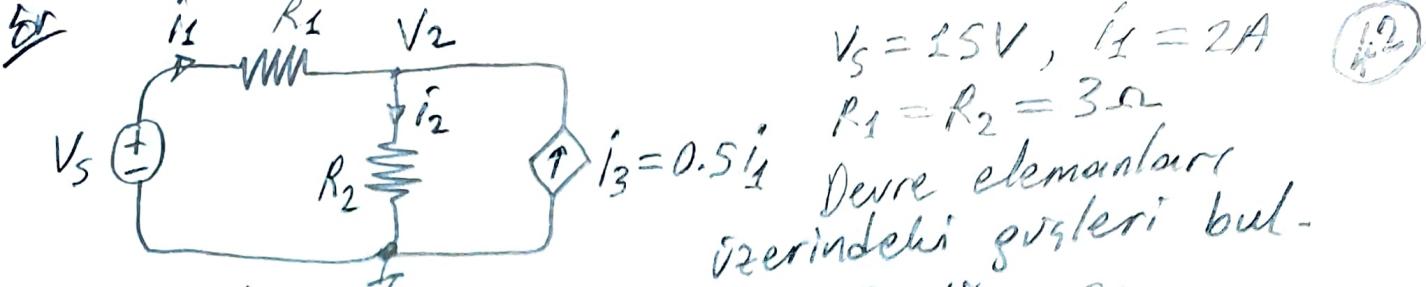
$$(V_L - 2)(2V_L + 5) = 0$$

$$V_L = 2V, V_L = -2.5V$$

$$V_L = 2V$$

$$i_L = 0.5 V_L^2 = 2A$$

$$R_L = \frac{V_L}{i_L} = \frac{2V}{2A} = 1\Omega$$



$$P_s = V_s i_1 = 15V \times 2A = 30W \text{ Üretilen } G_{\text{ü}}$$

$$i_3 = 0.5i_1 = 1A, i_2 = i_1 + i_3 = 2A + 1A = 3A$$

$$P_1 = R_1 i_1^2 = 3\Omega \times (2A)^2 = 12W \text{ Tüketilen } G_{\text{ü}}$$

$$P_2 = R_2 i_2^2 = 3\Omega \times (3A)^2 = 27W \text{ Tüketilen } G_{\text{ü}}$$

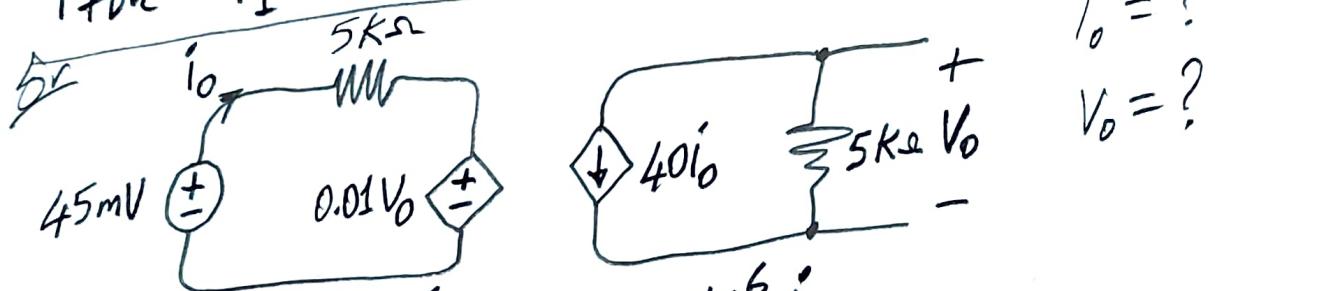
$$V_2 = R_2 i_2 = 3\Omega \times 3A = 9V$$

$$P_3 = V_2 \cdot i_3 = 9V \times 1A = 9W \text{ Üretilen } G_{\text{ü}}$$

$$P_{\text{üret}} = P_s + P_3 = 30W + 9W = 39W$$

$$P_{\text{tük}} = P_1 + P_2 = 12W + 27W = 39W$$


---



$$V_o = -5k\Omega \times 40i_o = -0.2 \times 10^6 i_o$$

$$45mA - 5k\Omega \cdot i_o - 0.01V_o = 0$$

$$45 \times 10^{-3} - 5 \times 10^3 i_o - 10^{-2} V_o = 0$$

$$45 - 5 \times 10^6 i_o - 10 V_o = 0$$

$$45 - 5 \times 10^6 i_o + 10 \times 0.2 \times 10^6 i_o = 0$$

$$45 - 3 \times 10^6 i_o = 0$$

$$i_o = \frac{45}{3 \times 10^6} A = 15 \mu A$$

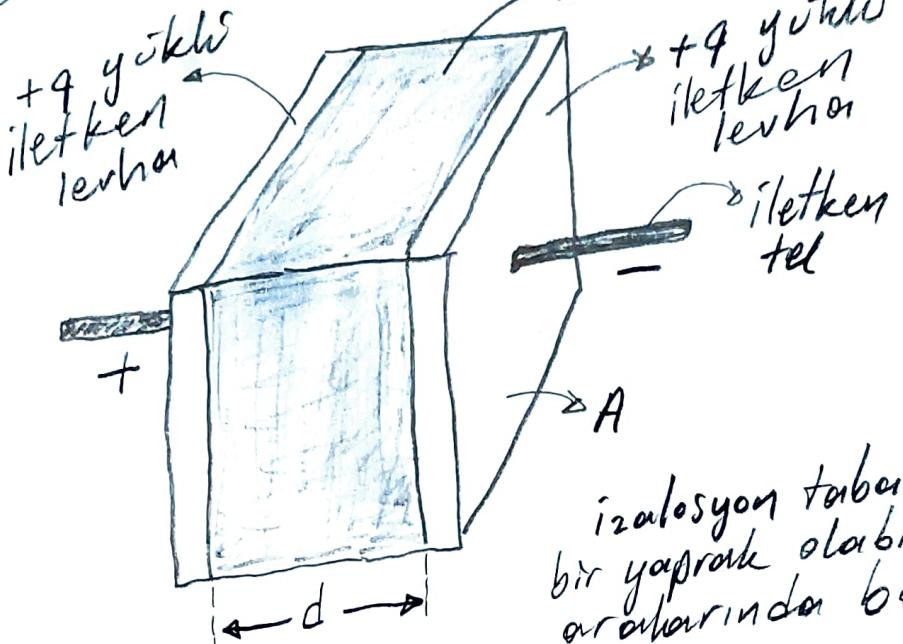
$$\begin{aligned} V_o &= -0.2 \times 10^6 i_o \\ &= -0.2 \times 10^6 \times 15 \times 10^{-6} V \\ &= -3V \end{aligned}$$

# Kapasitör (Kondansatör - Capacitor)

(4.3)

Kapasitörler, enerjiyi elektrik alanında depolayan devre elementleri dir. Elektrik alan varsa kapasitif etki vardır. Potansiyel farkının değişmesi yüklerin değişimle olur.

Kapasitörün şarj depolama kapasitesi kapasitans olarak adlandırılır. Kapasitörün sembolü C (Capacitor) birimi F (Farad)'dır.



A: Levhaların her birinin yüzey alanı

d: Levhalar arasındaki uzaklık veya izolasyon malzemesinin kalınlığı

izolasyon tabakası ince plastik bir yaprak olabilir gibi aralıklarında boşluklar olabilir.

$$C = \epsilon \frac{A}{d} = \epsilon_r \epsilon_0 \frac{A}{d} = \epsilon_r C_0$$

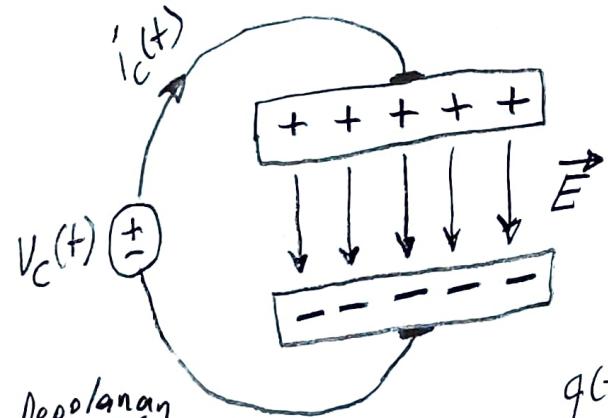
$\epsilon_r$  boşluk ısının 1, havanın ısin n1, silikon ısının 12 olur.

$$\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$$

Bölgule veya havanın Dielektrik katsayısı



$i_C(t)$  akımı kapasitörden geçen akım depolıdır. Tedden geçen akımdır.



Depolanan enerji

$$W_C(t) = \frac{1}{2} C V_C^2(t)$$

Birim Joule (J)

$$q(t) = C V_C(t)$$

$$C = \frac{q(t)}{V_C(t)}, \quad 1 \text{ Farad} = 1 \frac{\text{Coulomb}}{\text{Volt}}$$

Kapasitor üzerindeki voltaj artırsa tüketici, azalırsa üretici konumundadır.

Kapasitörler yüksek frekansda kısa devre olursa dreliyi gösterirler. Dolayısıyla fiz denilen yüksek frekansları geçirirler.

Ür 5  $\mu\text{F}$ 'lik bir kapasitorun iletkenin 12 V'lu bir gerilim uygulanıyor. Plakaların biriken yoku bulunuz. Kapasitorde depolanan enerjiyi bulunuz.

$$C = 5 \mu\text{F} \quad q = CV_C = 5 \mu\text{F} \times 12\text{V} = 60 \mu\text{C}$$

$$V_C = 12\text{V} \quad W_C = \frac{1}{2} CV_C^2 = \frac{1}{2} \times 5 \mu\text{F} \times (12\text{V})^2 = 0.36 \text{mJ}$$

Ür Bir kapasitorun plakaları arası 3 mm, plakaların yüzey alanı  $25 \text{ cm}^2$  olsun. Plakalar arasındaki yalıtkan malzemenin bağlı dielektrik katsayısı 8 olsun.

a) Kapasitorun kapasitansı nedir?

b) Yalıtkan malzemenin dayanabileceğin maksimum elektrik alanı  $10^5 \text{ V/m}$  ise kapasitorun taşıyabileceği maksimum voltaj ve yoku bulunuz?

$$\text{a)} \epsilon_r = 8, d = 3 \text{ mm} = 3 \times 10^{-3} \text{ m}, A = 25 \text{ cm}^2 = 25 \times 10^{-4} \text{ m}^2$$

$$C = \epsilon \frac{A}{d} = \epsilon_r \epsilon_0 \frac{A}{d}$$

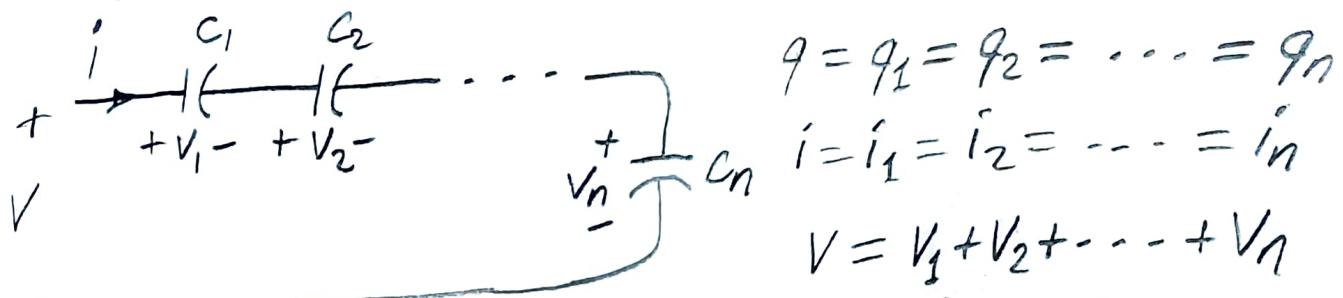
$$= 8 \times 8.85 \times 10^{-12} \times \frac{25 \times 10^{-4}}{3 \times 10^{-3}} \text{ F} = 59 \text{ pF}$$

$$\text{b)} V_C = E \times d = 10^5 \frac{\text{V}}{\text{m}} \times 3 \times 10^{-3} \text{ m} = 300 \text{ V}$$

$$q = CV_C = 59 \text{ pF} \times 300 \text{ V}$$

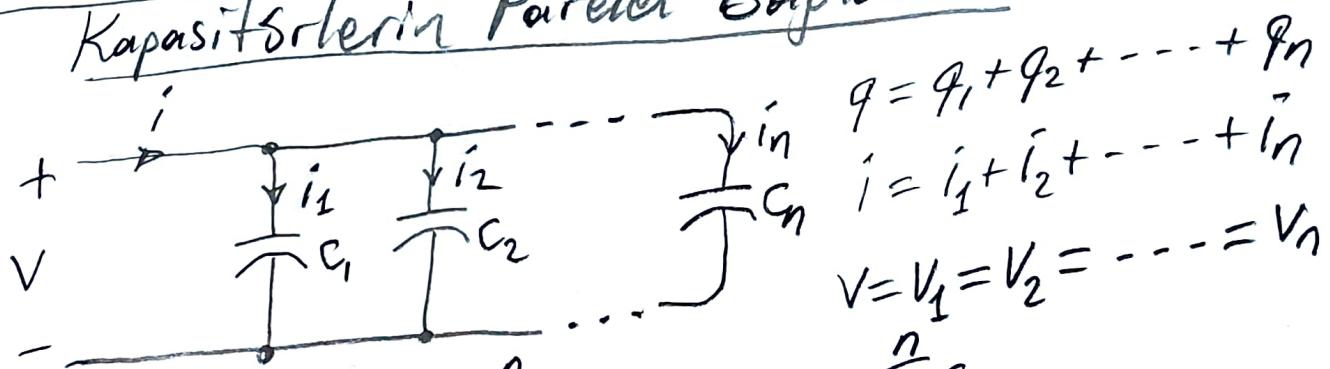
$$= 17.7 \text{ nC}$$

## Kapasitörlerin Seri Bağlanması



$$V = \sum_{k=1}^n V_k \Rightarrow \frac{Q}{C_e} = \sum_{k=1}^n \frac{Q}{C_k} \Rightarrow \frac{1}{C_e} = \sum_{k=1}^n \frac{1}{C_k}$$

## Kapasitörlerin Paralel Bağlanması



$$Q = \sum_{k=1}^n Q_k \Rightarrow C_e V = \sum_{k=1}^n C_k V \Rightarrow C_e = \sum_{k=1}^n C_k$$

$q(t) = C V_c(t)$ ,  $C$  zamanından bağımsız  
 $i_c(t) = \frac{dq(t)}{dt} = C \frac{dV_c(t)}{dt}$

$$V_c(t) = \frac{1}{C} \int_{-\infty}^t i_c(z) dz = V_c(t_0) + \frac{1}{C} \int_{t_0}^t i_c(z) dz$$
 $P_c(t) = \frac{dw_c(t)}{dt} = \frac{dw_c(t)}{dq(t)} \frac{dq(t)}{dt} = V_c(t) \cdot i_c(t)$

$$P_c(t) = V_c(t) \cdot i_c(t) = C V_c(t) \frac{dV_c(t)}{dt}$$
 $w_c(t) = \int_{-\infty}^t P_c(z) dz = C \int_{V_c(-\infty)}^{V_c(t)} V_c dV_c = \frac{1}{2} C V_c^2(t) = \frac{q^2(t)}{2C} = \frac{q(t)V(t)}{2}$

$$V_c(0^-) = V_c(0^+) \text{ olur.}$$

$$\frac{dV_c}{dt} = 0 \text{ ise } i_c = 0 \text{ olur.}$$

yani akıksız devre

$V_c$  sabit

**Kapasitörler** ;  
 düşük frekansta akıksız devre,  
 yüksek frekansta kısa devre  
 olurlar.

# Dalgalar Formları

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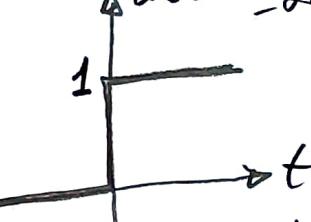
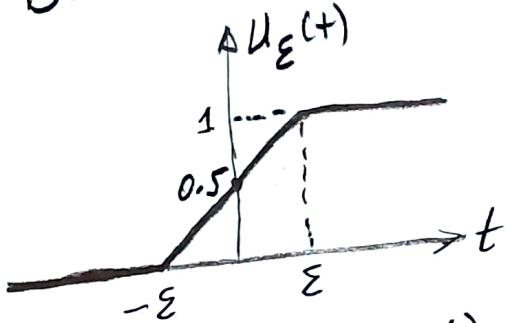
- ① Sabit fonksiyon  $f(t) = A$
  - ② Sinyoidal fonksiyon  $f(t) = A \sin(\omega t + \alpha)$
  - ③ Birim Dirfü Fonksiyon  $\delta_\varepsilon(t)$
- 
- $\int_{-\infty}^{\infty} \delta_\varepsilon(t) dt = \int_{-\varepsilon}^{\varepsilon} \frac{1}{\varepsilon} dt = 1$
- 
- $\int_{-\infty}^{\infty} \delta(t) dt = \int_0^0 \delta(t) dt = 1$
- $\varepsilon \rightarrow 0$  isin  $\delta_\varepsilon(t) \rightarrow \delta(t)$  olur.  $\delta(at) = \frac{\delta(t)}{|at|}$

$\delta(-t) = \delta(t)$  çift fonksiyondur.

$$\int_{-\infty}^{\infty} x(t) \delta(t) dt = \int_{-\infty}^{\infty} x(0) \delta(t) dt = x(0) \int_{-\infty}^{\infty} \delta(t) dt = x(0)$$

$$x(t) = \int_{-\infty}^{\infty} x(2) \delta(t-2) dt = x(t) * \delta(t)$$

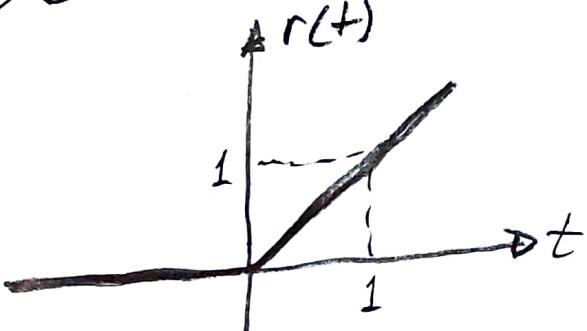
- ④ Birim Basamak Fonksiyonu



$$u(0^-) = 0, u(0^+) = 1, \quad s(t) = \frac{du(t)}{dt} = u'(t)$$

$\varepsilon \rightarrow 0$  tür.  $u_\varepsilon(t) \rightarrow u(t)$  olur.

- ⑤ Birim Ramp Fonksiyonu



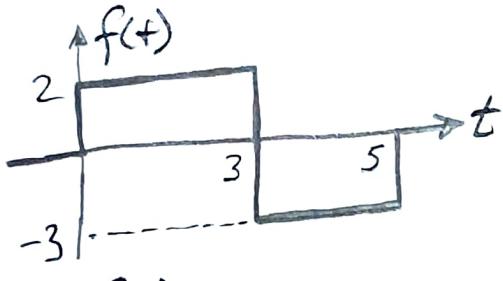
$$r(t) = \int_{-\infty}^t u(z) dz$$

$$= t u(t) = \begin{cases} t, & t \geq 0 \\ 0, & t < 0 \end{cases}$$

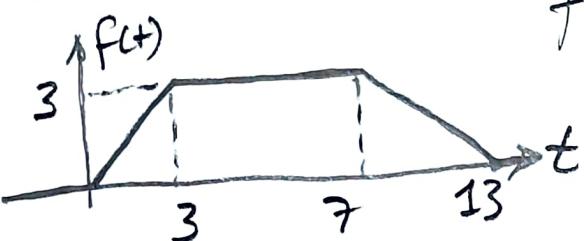
$$u(t) = r'(t) = \frac{dr(t)}{dt}$$

$$\delta(t) = u'(t) = r''(t)$$

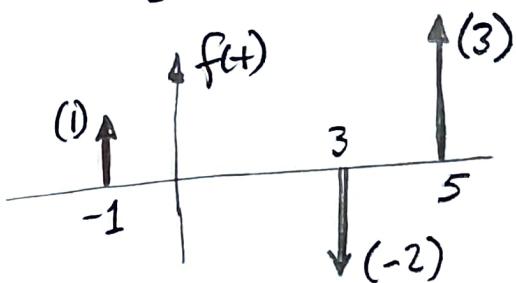
$$\begin{aligned} w &= 2\pi f \\ &= \frac{2\pi}{T} \end{aligned}$$



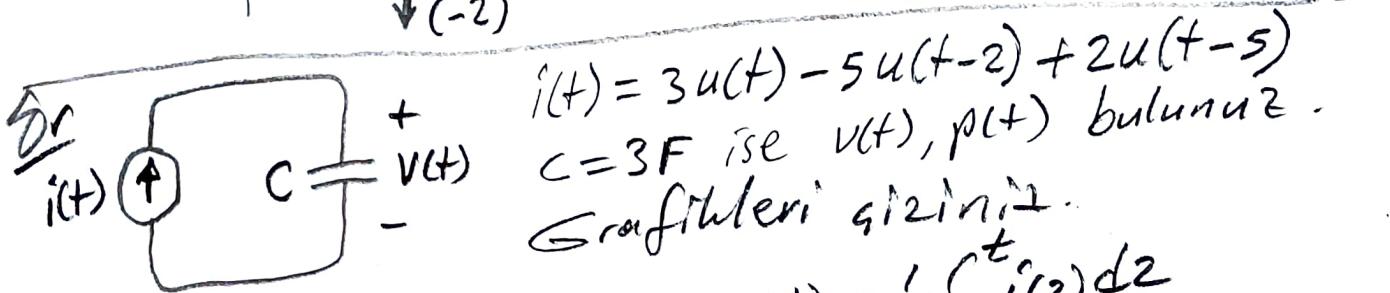
$$f(t) = 2u(t) - 5u(t-3) + 3u(t-5)$$



$$\begin{aligned} f(t) = & r(t) - r(t-3) \\ & - 0.5r(t-7) \\ & + 0.5r(t-13) \end{aligned}$$

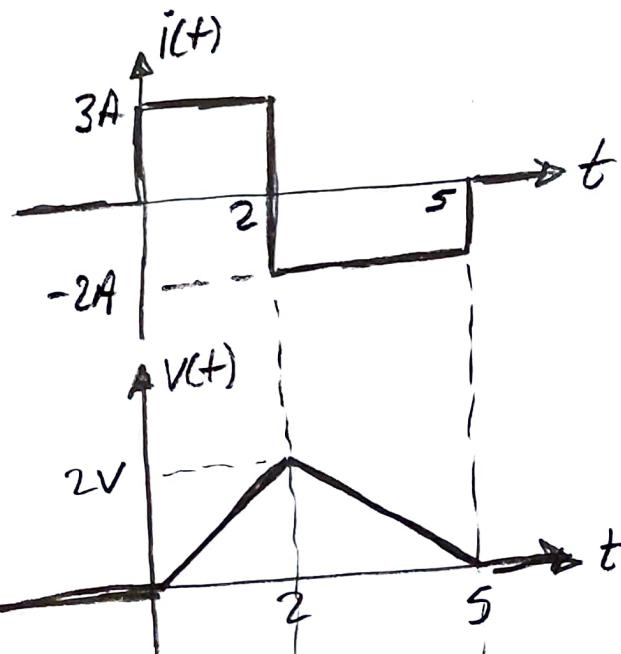


$$\begin{aligned} f(t) = & \delta(t+1) - 2\delta(t-3) \\ & + 3\delta(t-5) \end{aligned}$$

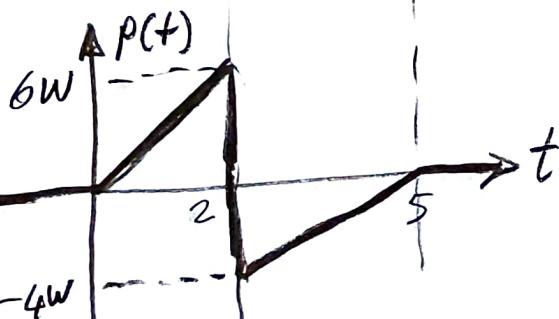
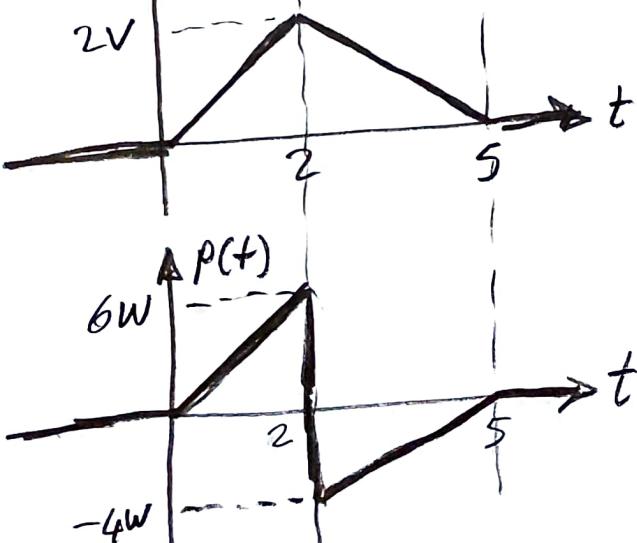


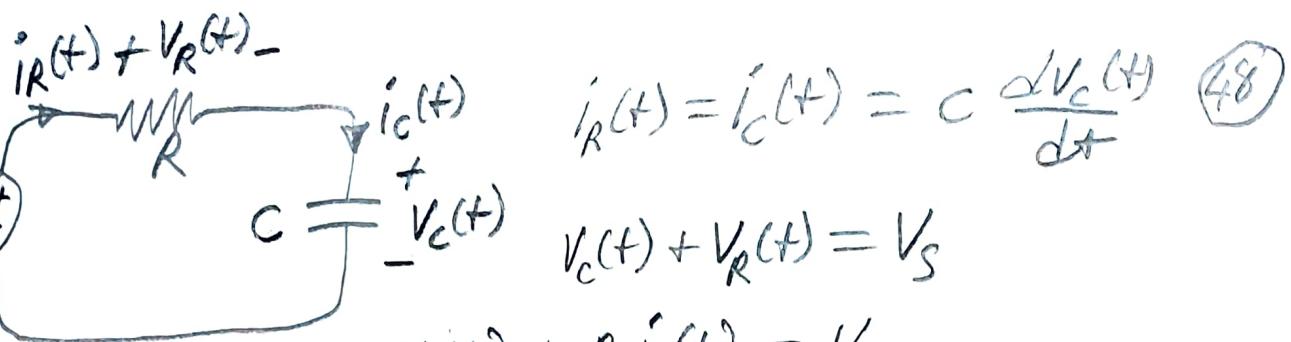
$$\begin{aligned} i(t) = & 3u(t) - 5u(t-2) + 2u(t-5) \\ C = 3F \text{ ise } & v(t), p(t) \text{ bulunur.} \\ \text{Grafikleri çiziniz.} & \end{aligned}$$

$$\begin{aligned} v(t) = & \frac{1}{C} \int_{-\infty}^t i(2) dt \\ = & r(t) - \frac{5}{3}r(t-2) + \frac{2}{3}r(t-5) \end{aligned}$$



$$\begin{aligned} r(t) = & 3r(t) - 10u(t-2) \\ & - \frac{5}{3}r(t-2) - \frac{4}{3}r(t-5) \end{aligned}$$





$$i_R(t) = i_C(t) = C \frac{dV_C(t)}{dt} \quad (48)$$

$$V_C(t) + V_R(t) = V_S$$

$$V_C(t) + R i_R(t) = V_S$$

$$V_C(t) + RC \frac{dV_C(t)}{dt} = V_S \Rightarrow \frac{dV_C(t)}{dt} + \frac{1}{RC} V_C(t) = \frac{V_S}{RC}$$

$t=0^+$  zamankinden itibaren devreye  $V_S$  sabit gerilimiği veriliyor.

$$Z = RC$$

$$V_C(t) = (A e^{-t/RC} + B) u(t)$$

$$\text{yada } V_C(t) = A e^{-t/RC} + B, t \geq 0$$

$$V_C(0^+) = V_0, V_C(\infty) = V_S$$

$$t=\infty \text{ için } B = V_S$$

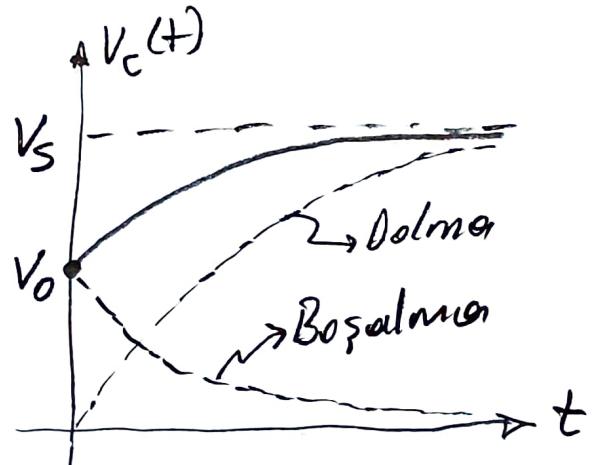
$$t=0^+ \text{ için } A+B = V_0 \Rightarrow A = V_0 - V_S$$

$$V_C(t) = (V_0 - V_S) e^{-t/RC} + V_S$$

$$= \underbrace{V_0 e^{-t/RC}}_{\text{Boşalma}} + \underbrace{V_S (1 - e^{-t/RC})}_{\text{Dolma}}, t \geq 0$$

$$i_C(t) = C \frac{dV_C(t)}{dt} = \frac{V_S - V_C}{R}$$

$$= \frac{V_S - V_0}{R} e^{-t/RC}, t \geq 0$$



$t = 5Z = 5RC$  'de  
kapasitörün doldugu  
veya boşalığı kabul ediliyor.