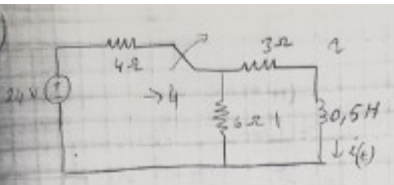
3)



$i_L(t) = ?$

$V_L(t) = ?$

$i_L(0^-) = 4\,\frac{6}{3+6} = \frac{24}{9} = \frac{8}{3}$

$i_L(0^+) = i_L(0^-)$

$i_L(\infty) = 0$

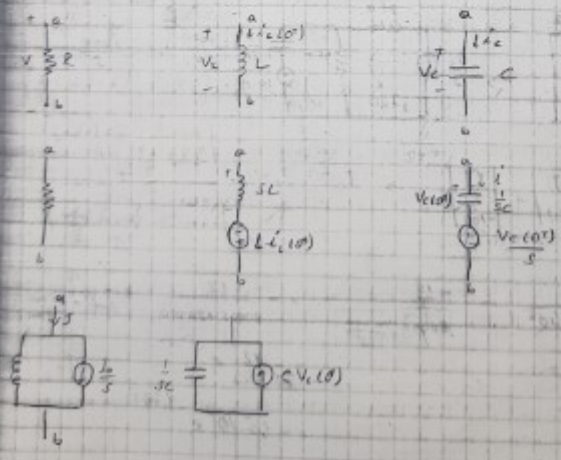
$\tau = \frac{L}{R_{eş}} = \frac{0,5}{9} = \frac{1}{18}$

$i_L(t) = A\,e^{-t/\tau} \Rightarrow \frac{8}{3} = A$ (1)

$= \frac{8}{3}\,e^{-18t}$

$V_L(t) = L\,\frac{di_L}{dt} = 0,5 \cdot (-18) \cdot \frac{8}{3}\,e^{-18t}$

S Domeninde Devre Çözümü



$x_L = (j\omega L)$ t domeni

(sL) s "

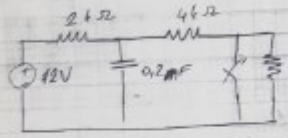
$x_C = \left(\frac{1}{j\omega C}\right)$ t domeni

$$i_c = C \frac{dV_c}{dt}$$

$$I = C[sV - V_c(0^+)] = sCV - CV_c(0^+)$$

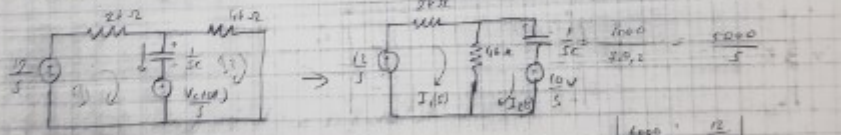
$$V = \frac{1}{sC} I + \frac{V_c(0^+)}{s}$$

(4)



$$V_c(0^-) = \frac{12}{(2+4+6)\cdot 10^3} \cdot (4+6)\cdot 10^3 = 10V$$

$$V_c(0^+) = V_c(0^-) = 10V$$

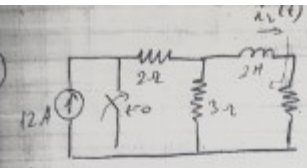


$$\begin{vmatrix} 6000 & -4000 \\ -4000 & 4000 + \frac{5000}{s} \end{vmatrix} \begin{vmatrix} I_1(s) \\ I_2(s) \end{vmatrix} = \begin{vmatrix} \frac{12}{s} \\ -\frac{10}{s} \end{vmatrix} \rightarrow I_c(s) = I_2(s) = \frac{\begin{vmatrix} 6000 & \frac{12}{s} \\ -4000 & -\frac{10}{s} \end{vmatrix}}{\begin{vmatrix} 6000 & -4000 \\ -4000 & 4000 + \frac{5000}{s} \end{vmatrix}}$$

$$I_c(s) = \frac{-\frac{60000}{s} + \frac{48000}{s}}{24 \cdot 10^6 + \frac{20 \cdot 10^4}{s} - 16 \cdot 10^6} = \frac{-\frac{12}{s}}{8000 + \frac{80000}{s}} = \frac{-12}{8000s + 80000} = \frac{12}{8000s + 80000}$$

$$= -\frac{12}{8000} e^{-10/s} = -1{,}5 \cdot 10^{-3} e^{-3{,}75t}$$

15)



t doneride

S " 6Ω

t doneni

$i_L(0^-) = 12 \frac{3}{3+6} = 4A$

$i_L(\infty) = 0$

$\tau = \frac{L}{R_{eq}} = \frac{2}{\frac{3 \cdot 3}{3+3} + 6} = \frac{10}{36}$

$i_L(t) = Ae^{-t/\tau} + i_L(\infty)$

$4 = A$

$i_L(t) = 4e^{-3,6t}$

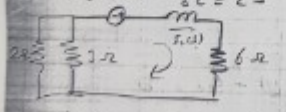
$V_L(t) = L \frac{di_L}{dt}$

$= 2 \cdot (-3,6) \cdot 4e^{-3,6t}$

$= 28,8\, e^{-3,6t}$

S doneni

$i_L(0) \cdot 4 \cdot 8$ $\quad sL = 2s$

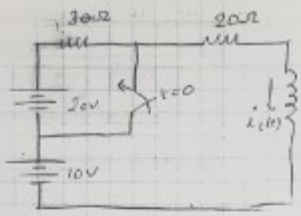


$\left(\frac{6}{s} + 2s + 6\right) I_L(s) - 8 = 0$

$I_L(s) = \frac{8}{\frac{36}{5} + 2s} = \frac{8}{2s + \frac{36}{5}} = \frac{4}{s + 3,6}$

$I_L(t) = 4e^{-3,6t}\ A$

16)



$t=0$ quando chaveia

t depois

∞ depois

t depois

$$i_L(0^-) = \frac{10+20}{30+20} = 0,6\,A$$

$$i_L(0^+) = i_L(0^-)$$

$$i_L(\infty) = \frac{10}{20} = 0,5\,A$$

$$\tau = \frac{L}{R_{eq}} = \frac{0,5}{20} = \frac{1}{40}$$

$$i_L(t) = A e^{-t/\tau} + i_L(\infty)$$

$$0,6 - 0,5 = A$$

$$0,1 = A$$

$$i_L(t) = 0,1\,e^{-40t} + 0,5$$

$$V_L(t) = L\frac{di_L}{dt}$$

$$= 0,5 \cdot 0,1 (-40) \cdot e^{-40t}$$

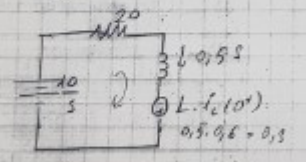
$$= -2e^{-40t}$$

$V_L(0^+) = 5$

$V_L(\infty) = 0$

$V_L(t\to\infty) = 0$

t depois



$$-\frac{10}{s} + (20+0,5s)I_L(s) - 0,3 = 0$$

$$I_L(s) = \frac{0,3 + 10/s}{0,5s+20} = \frac{10+0,3s}{0,5s^2+20s}$$

$$= \frac{20+0,6}{s(s+40)} = \frac{A}{s} + \frac{B}{s+40}$$

$$A(s+40) + Bs = 20+0,6$$

$A+B = 0,6$

$40A = 20$

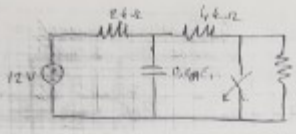
$A = 0,5$

$B = 0,1$

$$\frac{0,5}{s} + \frac{0,1}{s+40}$$

$$I_L(t) = 0,1\,e^{-40t} + 0,5$$

18)



t = 0 anında açılıyor

t domeni

s "

t domeninde

$V_c(0^-) = \frac{12}{2+4} \cdot 4 = 8\,V$ $\qquad V_c(0^+) = V_c(0^-)$

$V_c(\infty) = \frac{12}{4+2} \cdot 10 = 10\,V$

$\tau = C R_{eq} = 0{,}2 \cdot 10^{-3} \cdot \frac{2 \cdot 10^3 (4+6) 10^3}{(2+4+6) \cdot 10^3} = \frac{1}{15}$

$V_c(t) = A e^{-t/\tau} + V_c(\infty)$

$8 = -10 + A$

$A = 18$

$V_c(t) = -2 e^{-3t} + 10$

$i_c(t) = C \frac{dV_c}{dt}$

$= 0{,}2 \cdot 10^{-3} \cdot -2 \cdot -3 e^{-3t}$

$= 1{,}2 \cdot 10^{-3} e^{-3t}$

s domeninde

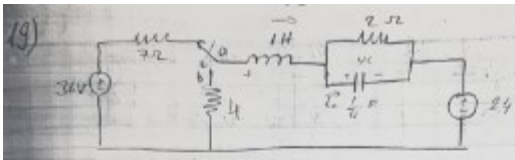
$$\begin{vmatrix} 12000 & -10000 \\ -10000 & 10000 + \frac{5000}{s} \end{vmatrix} \begin{vmatrix} I_1 \\ I_2 \end{vmatrix} = \begin{vmatrix} 12/s \\ -8/s \end{vmatrix}$$

$$I_2(s) = I_c(s) = \frac{\begin{vmatrix} 12000 & 12/s \\ -10000 & -8/s \end{vmatrix}}{\begin{vmatrix} 12000 & -10000 \\ -10000 & 10000 + \frac{5000}{s} \end{vmatrix}} = \frac{-36.10^3 + 120.10^3}{s} \Big/ \frac{120.10^4 + 60.10^4 - 100.10^6}{s}$$

$$= \frac{24}{s} \Big/ \frac{20.10^3 + 60.10^3}{s} + \frac{24}{60.10^3 + 20.10^3 s}$$

$$= \frac{24}{80.10^3 s} \cdot \frac{1}{s+3}$$

19)



Anahtar uzun süre a konumunda kalıktan sonra b konumuna alınıyor

$I_L, V_L, I_c, V_c = ?$

$i_L(0^-) = \frac{36-24}{7+2} = \frac{12}{9} = \frac{4}{3}\,A$ $\qquad i_L(0^+) = i_L(0^-)$

$i_L(\infty) = -\frac{24}{6} = -4\,A$

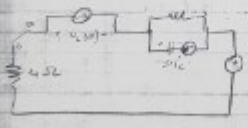
$V_c(0^-) = \frac{4}{3} \cdot 2 = \frac{8}{3}$ $\qquad V_c(0^+) = V_c(0^-)$

$i_c(0^-) = 0$ $\qquad V_L(\infty) = 0$

$i_c(\infty) = 0$ $\qquad V_L(0^-) = 0$

C 0⁺ anında kısa devre etkisi gösterdiğinden

self de i değişmediğinden



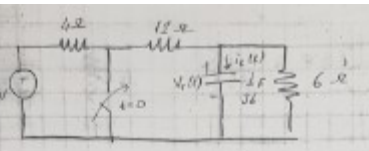
$V_L(0^+) + \frac{8}{3} + 24 + 4 \cdot i_L(0^+) = 0$

$V_L(0^+) = -32\,V$

$I_L(0^+) = \frac{\frac{8}{3}}{2} + i_c(0^+)$

$\frac{4}{3} = \frac{4}{3} + i_c(0^+) \Rightarrow i_c(0^+) = 0$

21.)



$t=0$ anında kapatılıyor.

$V_c(t)$, $i_c(t)$ ve i bul.

$V_c(0^-)$, $V_c(0^+)$, $V_c(\infty)$

$i_c(0^-)$, $i_c(0^+)$, $i_c(\infty)$

$\tau = R_{eq} C = \frac{12 \cdot 6}{12+6} \cdot \frac{1}{36} = \frac{1}{3}$

$V_c(0^-) = \frac{110}{22} \cdot 6 = 30\ V$ $\quad V_c(0^+) = V_c(0^-)$ $\quad V_c(\infty) = 0$

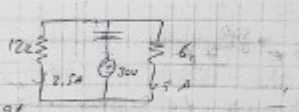
$V_c(t) = A e^{-3t} + 0$

$30 = A$

$V_c(t) = 30 e^{-3t}$

$i_c(t) = C \frac{dV_c}{dt} = \frac{1}{36} \cdot 30 \cdot -3 \cdot e^{-3t}$

$= -7{,}5\, e^{-3t}$



$i_c(t) = A e^{-3t} + 0$

$-7{,}5 = A$

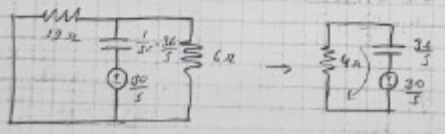
$i_c(t) = -7{,}5 e^{-3t}$

$i_c(0^-) = 0$

$i_c(0^+) = -7{,}5A$

$i_c(\infty) = 0$

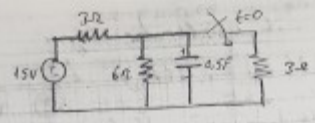
s domeninde



$\left(4 + \frac{36}{s}\right) I_c(s) + \frac{30}{s} = 0$

$I_c(s) = \frac{-30/s}{\frac{4s+36}{s}} = \frac{-7{,}5}{s+9} \Rightarrow I_c(t) = -7{,}5 e^{-9t}$

22)



$t \geq 0$ için V_c

$\tau = (3 // 6 // 3)\ 0{,}5 = 3/5$

$V_c(0^-) = \frac{15}{6+3} \cdot 6 = 10\,V$ $\qquad V_c(0^+) = V_c(0^-)$

$V_c(\infty) = \frac{15}{\frac{3\cdot 6}{3+6}+3} \cdot \frac{6}{3+6} \cdot 3 = 6\,V$

$V_c(t) = Ae^{-t/\tau} + V_c(\infty)$

$10 = A + 6$

$4 = A$

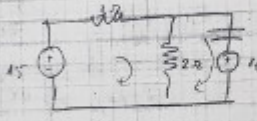
$V_c(t) = 4e^{-\frac{5}{3}t} + 6$

$i_c(0^-) = 0$ $\qquad i_c(\infty) = 0$

$i_c(0) = -\frac{10}{3}$

$i_c(t) = C\frac{dV_c}{dt} = \frac{1}{2} \cdot 4 \cdot -\frac{5}{3} e^{-5/3 t}$

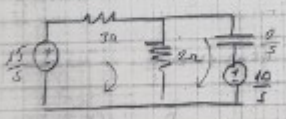
$= -\frac{10}{3} e^{-\frac{5}{3}t}$



$$\begin{bmatrix} 3+2 & -2 \\ -2 & 2 \end{bmatrix} \begin{bmatrix} I_1 \\ I_c \end{bmatrix} = \begin{bmatrix} 15 \\ -10 \end{bmatrix}$$

$$I_c = \frac{\begin{vmatrix} 5 & 15 \\ -2 & -10 \end{vmatrix}}{\begin{vmatrix} 5 & -2 \\ -2 & 2 \end{vmatrix}} = -\frac{10}{3}$$

S domeni

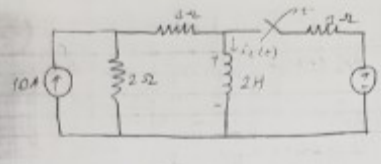


$$\begin{bmatrix} 3+2 & -2 \\ -2 & 2+\frac{2}{5} \end{bmatrix} \begin{bmatrix} I_1 \\ I_c \end{bmatrix} = \begin{bmatrix} 15/s \\ -10/s \end{bmatrix}$$

$$I_c(s) = \frac{\begin{vmatrix} 5 & 15/s \\ -2 & -10/s \end{vmatrix}}{\begin{vmatrix} 5 & -2 \\ -2 & \frac{25+9}{5} \end{vmatrix}} = \frac{-\frac{50}{s} + \frac{30}{s}}{\frac{105+10}{5} - 4} = \frac{-\frac{20}{s}}{\frac{(5+10)}{5}} = \frac{-20}{6(5+\frac{10}{6})}$$

$$I_c(t) = -\frac{10}{3} e^{-5/3 t}$$

23)



$I_L(t) \dots e\ 10\ V_C$

$\tau = \frac{L}{R_{eq}} = \frac{2}{3+2} = \frac{2}{5}$

$i_L(0^-) = i_{L_1}(0^-) + i_{L_2}(0^-)$

$= 10 \cdot \frac{2}{2+3} + \frac{10}{3}$

$= \frac{22}{3}\ A$

$i_L(t) = A e^{-t/\tau} + i_L(\infty)$

$\frac{22}{3} = A + 4$

$A = \frac{10}{3}$

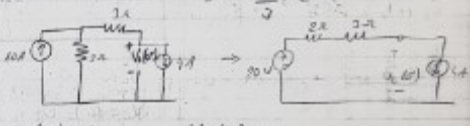
$i_L(t) = \frac{10}{3} e^{-\frac{5}{2}t} + 4$

$i_L(0^+) = i_L(0^-)$

$i_L(\infty) = 10 \frac{2}{2+3} = 4\ A$

$V_L(t) = L \frac{di_L}{dt} = 2 \cdot \frac{10}{3} \cdot -\frac{5}{2} e^{-5/2 t}$

$= -\frac{50}{3} e^{-2.5t}$



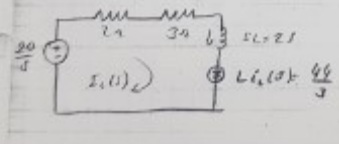
$V_L(0^+) = 0$ $\quad V_L(\infty) = 0$

$V_L(0^+) = 20 - (2+3)\frac{22}{3} \Rightarrow V_L(0^+) = -\frac{50}{3}$

$V_L(t) = A e^{-t/\tau} + V_L(\infty)$

$-\frac{50}{3} = A \Rightarrow V_L(t) = -\frac{50}{3} e^{-2.5t}$

S domeni



$-\frac{20}{s} + (5+2s) I_L(s) - \frac{44}{3} = 0$

$\frac{\frac{20}{s} - \frac{44}{3}}{5+2s} = I_L(s)$

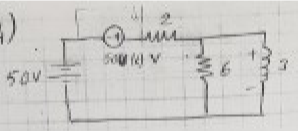
$I_L(s) = \frac{10 + \frac{22}{3}s}{s(s+2.5)} = \frac{A}{s} + \frac{B}{s+2.5}$

$A = 4 \qquad B = \frac{22}{3} - 4 = \frac{10}{3}$

$I_L(s) = \frac{4}{s} + \frac{10/3}{s+2.5}$

$i_L(t) = \frac{10}{3} e^{-2.5t} + 4$

24)



$V_L(t)$ ve $i_L(t)$'yi bul.

u(t) → basamak fonksiyonu ikinci durumda devreye girer.
1. durum: 50 u(t) kısa devre
2. durum: 50 u(t) var.

$i_L(0^-) = \frac{50}{2} = 25\,A$

$i_L(0^+) = i_L(0^-)$

$i_L(\infty) = \frac{50+50}{2} = 50\,A$

$i_L(t) = Ae^{-t/\tau} + i_L(\infty)$

$25 = A + 50$

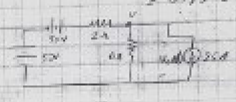
$A = -25$

$i_L(t) = -25e^{-0,5t} + 50$

$\tau = \frac{L}{R_{eş}} = \frac{3}{\frac{2 \cdot 6}{2+6}} = 2$

$V_L(t) = L\frac{di_L}{dt} = 3 \cdot -25 \cdot -0,5 \cdot e^{-0,5t}$

$= 37,5\,e^{-0,5t}$



$\frac{V_L(0^+) - 100}{2} + \frac{v}{6} + 25 = 0$

$V_L(0^-) = 0$

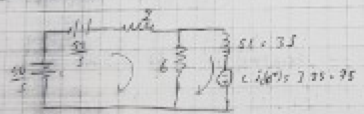
$V_L(\infty) = 0$

$v = 37,5\,V$

$V_L(t) = Ae^{-t/\tau}$

$37,5 = A \Rightarrow V_L(t) = 37,5\,e^{-0,5t}$

S domeni



$$\begin{bmatrix} 8 & -6 \\ -6 & 6+3s \end{bmatrix} \begin{bmatrix} I_1 \\ I_L \end{bmatrix} = \begin{bmatrix} 100/s \\ 75 \end{bmatrix}$$

$$I_L(s) = \frac{\begin{vmatrix} 8 & 100/s \\ -6 & 75 \end{vmatrix}}{\begin{vmatrix} 8 & -6 \\ -6 & 6+3s \end{vmatrix}} = \frac{600 + \frac{600}{s}}{48+24s-36} = \frac{600s+600}{s(24s+12)} = \frac{A}{s} + \frac{B}{24s+12}$$

$24As + 12A + Bs = 600s + 600$

$12A = 600$

$A = 50$

$24A + B = 600$

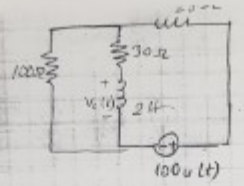
$B = -600$

$I_L(s) = +\frac{50}{s} - \frac{600}{24(s+\frac{1}{2})}$

$= \frac{50}{s} - \frac{25}{s+\frac{1}{2}}$

$= -25e^{-0,5t} + 50$

25)



$i_L(0^-) = i_L(0^+) = 0$

$i_L(\infty) = \frac{100}{\frac{30 \cdot 100}{100+30} + 25} \cdot \frac{100}{100+30} = 1,6\,A$

$\tau = \frac{L}{R_{eq}} = \frac{2}{\frac{100 \cdot 25}{100+25} + 30} = \frac{1}{25}$

$i_L(t) = Ae^{-t/\tau} + i_L(\infty)$

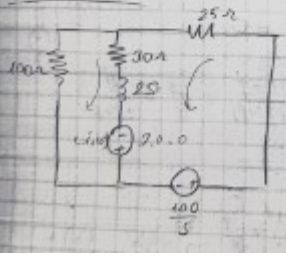
$0 = A + 1,6$

$A = -1,6$

$i_L(t) = -1,6\,e^{-25t} + 1,6$

$V_L(t) = L\frac{di_L}{dt} = 2 \cdot -1,6 \cdot -25 \cdot e^{-25t} = 80\,e^{-25t}$

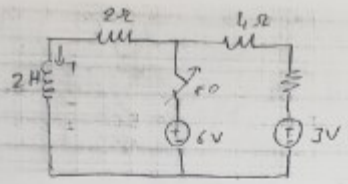
S domeni



$\begin{bmatrix} 130+2S & 30+2S \\ 30+2S & 50+2S \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 100/S \end{bmatrix}$

$I_1 = \frac{\begin{vmatrix} 0 & 30+2S \\ 100/S & 50+2S \end{vmatrix}}{\begin{vmatrix} 130+2S & 30+2S \\ 30+2S & 50+2S \end{vmatrix}} =$

26)



$i_L(0^-) = \frac{6}{\frac{2 \cdot 6}{2+6}} \cdot \frac{6}{2+6} + 0 = 3\,A \qquad i_L(0^+) = i_L(0^-)$

$i_L(\infty) = \frac{3}{8}\,A$

$i_L(t) = Ae^{-t/\tau} + i_L(\infty)$

$3 = A + \frac{3}{8} \Rightarrow A = +\frac{21}{8}$

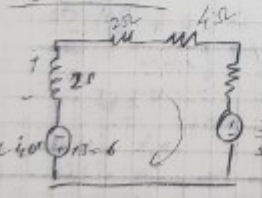
$i_L(t) = \frac{21}{8}e^{-4t} + \frac{3}{8}$

$V_L(t) = L\frac{di_L}{dt}$

$= 2 \cdot \frac{21}{8} \cdot -4\,e^{-4t}$

$= -21\,e^{-4t}$

S domeni

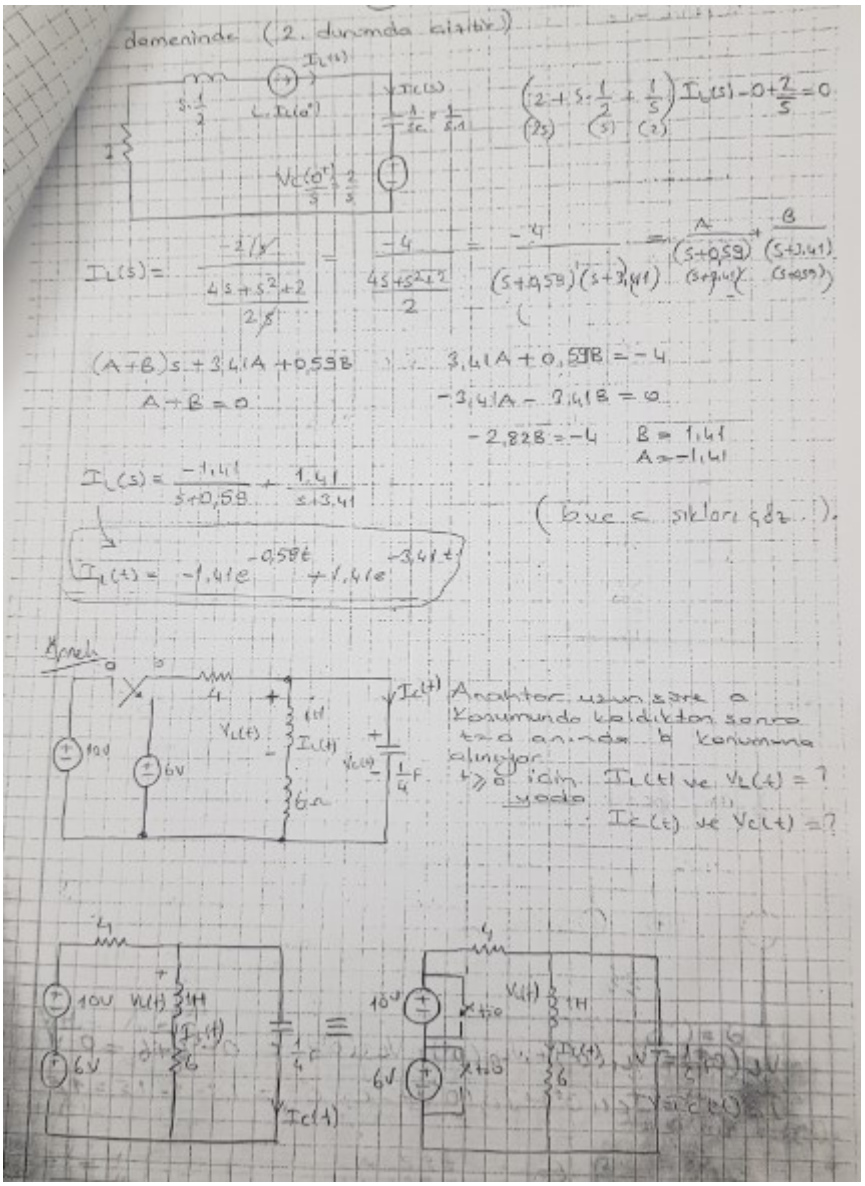


$-6 + (2S+8)I_L(S) - \frac{3}{S} = 0$

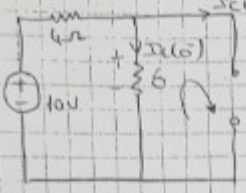
$I_L(S) = \frac{\frac{3}{S}+6}{2S+8} = \frac{6S+3}{S(2S+8)} = \frac{A}{S} + \frac{B}{2S+}$

$A = \frac{3}{8} \qquad B = \frac{21}{4}$

$I_L(S) = \frac{3}{8S} + \frac{21}{8(S+4)} \Rightarrow i_L(t) = \frac{21}{8}e^{-4t} + \frac{3}{8}$


demeninde (2. durumda cizilir)
$I_L(s) = \frac{-2/s}{\frac{4s+s^2+2}{2s}} = \frac{-4}{4s+s^2+2} = \frac{-4}{(s+0,59)(s+3,41)} = \frac{A}{(s+0,59)} + \frac{B}{(s+3,41)}$
$(A+B)s + 3,41A + 0,59B$
$A+B=0$
$3,41A + 0,59B = -4$
$-3,41A - 3,41B = 0$
$-2,828 = -4$
$B = 1,41$
$A = -1,41$
$I_L(s) = \frac{-1,41}{s+0,59} + \frac{1,41}{s+3,41}$
$i_L(t) = -1,41e^{-0,59t} + 1,41e^{-3,41t}$
Anahtar uzun süre a konumunda kalıdıktan sonra t=0 anında b konumuna alınıyor.
İstenen: $I_L(t)$ ve $V_L(t) = ?$
$I_C(t)$ ve $V_C(t) = ?$
10V
6V
4Ω
6Ω
1H
1/4 F
$V_L(t)$
$I_L(t)$
$I_C(t)$
$V_{C(0)}$

1. durum devresi (anahtar a konumunda)

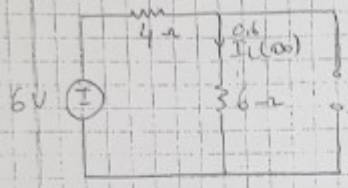


$-V_C(0^-) + 6.1 = 0$

$-V_C(0^-) = -6\,V$

$V_C(0^-) = 6\,V = V_{C_1}$

$I_C(0^-) = V_C(0^-) = 0$

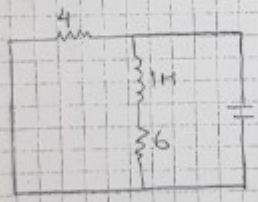


$I_L(\infty) = 0{,}6A = \frac{6}{10}$

$-V_C(\infty) + 6 \times 0{,}6 = 0 \Rightarrow$

$-V_C(\infty) = 3{,}6\,V$

$I_C(\infty) = 0$



$\frac{1}{4} + \frac{1}{r+6} + \frac{1}{r \cdot \frac{1}{4}} = 0$

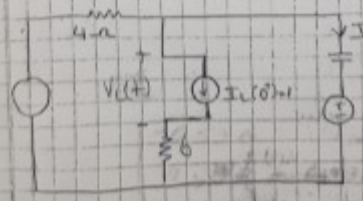
$\frac{1}{4} + \frac{1}{r+6} + \frac{r}{4}$

$\frac{r+1}{4} + \frac{1}{r+6} = 0 \Rightarrow r^2+6r+r+6+4=0$

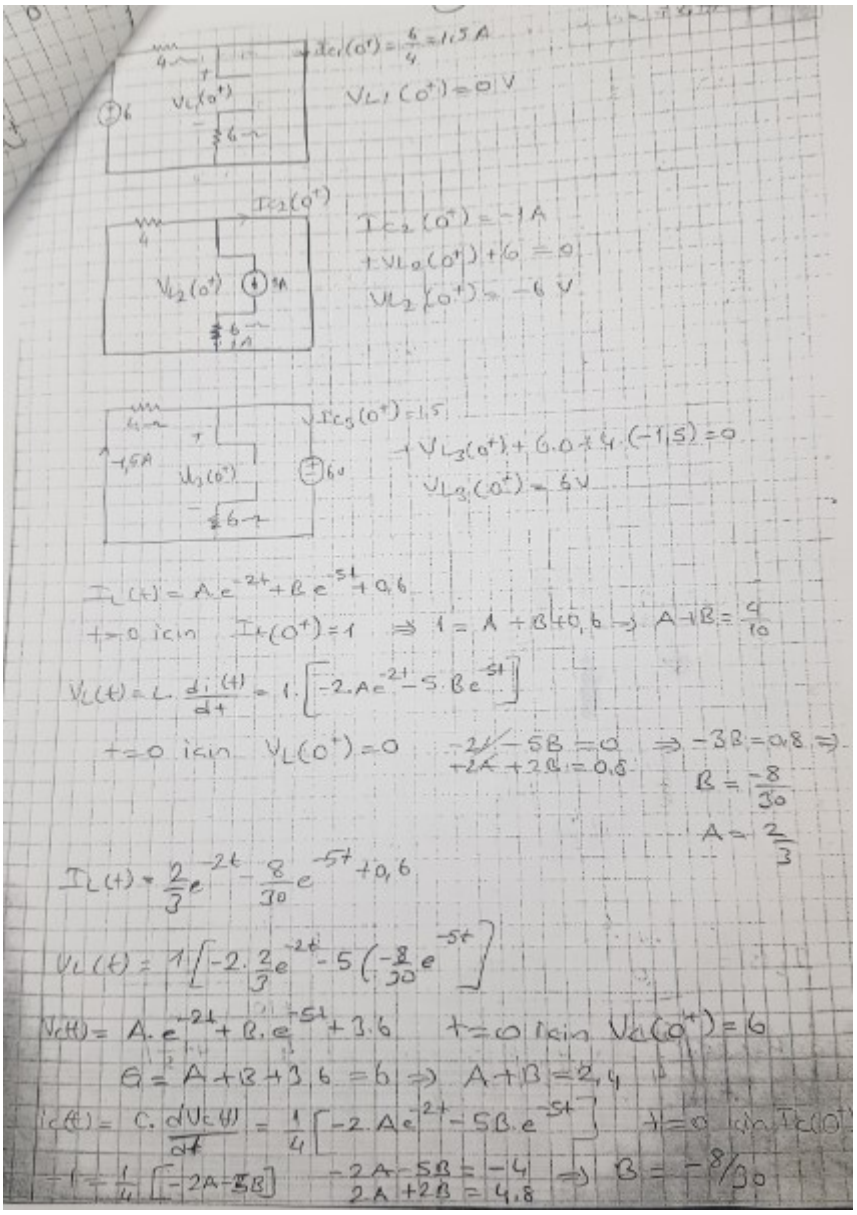
$(r+6)\quad(4) \qquad \Rightarrow r^2+7r+10=0$

$=(r+2)(r+5)$

0^+ anı eşdeğer devresi



$V_L(0^+) = V_{L_1}(0^+) + V_{L_2}(0^+) + V_{L_3}(0^+) = 0 - 6 + 6 = 0$



$i_L(t) = A.e^{-2t} + B.e^{-5t} + 0,6$

$t=0$ için $I_L(0^+) = 1 \Rightarrow 1 = A + B + 0,6 \rightarrow A + B = \frac{4}{10}$

$V_L(t) = L.\frac{di_L(t)}{dt} = 1.\left[-2.Ae^{-2t} - 5.Be^{-5t}\right]$

$t=0$ için $V_L(0^+) = 0$ $\quad -2A - 5B = 0 \quad \Rightarrow -3B = 0,8 \Rightarrow$

$+2A + 2B = 0,8$ $\quad B = \frac{-8}{30}$

$A = \frac{2}{3}$

$I_L(t) = \frac{2}{3}e^{-2t} - \frac{8}{30}e^{-5t} + 0,6$

$V_L(t) = 1.\left[-2.\frac{2}{3}e^{-2t} - 5\left(\frac{-8}{30}e^{-5t}\right)\right]$

$V_c(t) = A.e^{-2t} + B.e^{-5t} + 3,6$ $\quad t=0$ için $V_c(0^+) = 6$

$6 = A + B + 3,6 = 6 \Rightarrow A + B = 2,4$

$i_c(t) = C.\frac{dV_c(t)}{dt} = \frac{1}{4}\left[-2.Ae^{-2t} - 5B.e^{-5t}\right]$ $\quad t=0$ için $I_c(0^+)$

$-1 = \frac{1}{4}\left[-2A - 5B\right]$ $\quad -2A - 5B = -4 \Rightarrow B = -8/30$

$2A + 2B = 4,8$

$A+B=\frac{24}{10}$

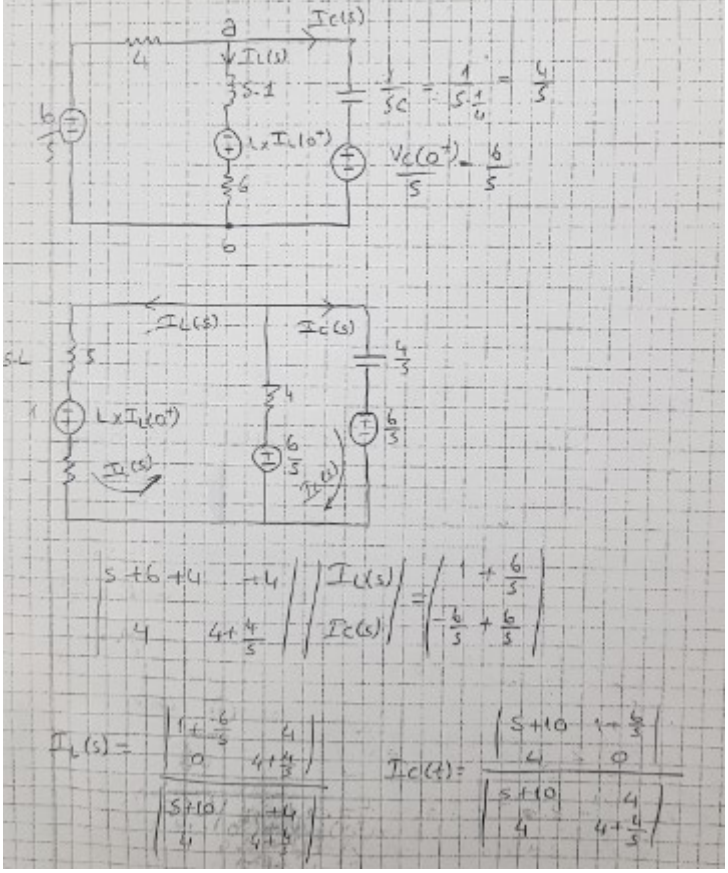
$A=-\frac{8}{30}+\frac{72}{30}$

$A=\frac{8}{3}$

$V_c(t)=A\cdot e^{-2t}+B\cdot e^{-5t}+3,6$

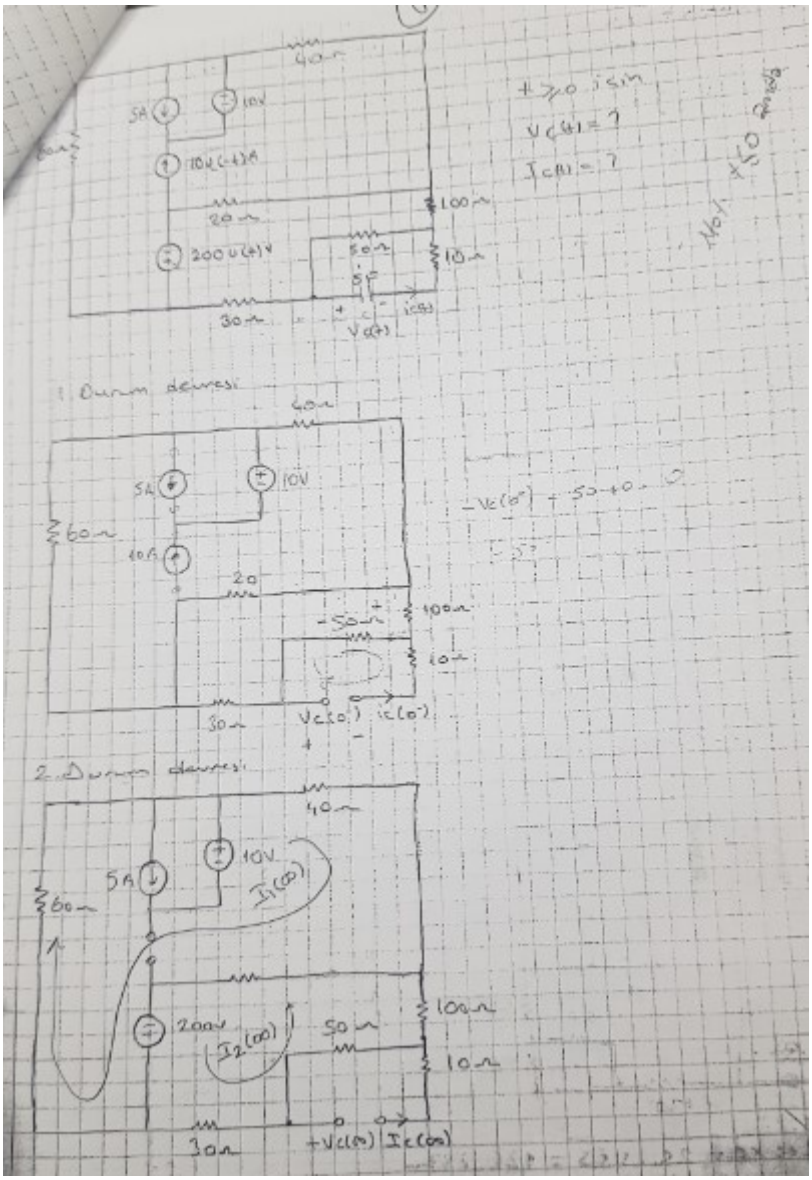
$V_c(t)=\frac{8}{3}e^{-2t}-\frac{8}{3}e^{-5t}+3,6$

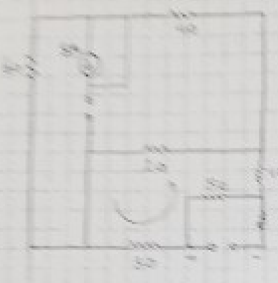
$I_c(t)=\frac{1}{4}\left[-2\left(\frac{8}{3}\right)e^{-2t}-5\left(-\frac{8}{30}\right)e^{-5t}\right]$

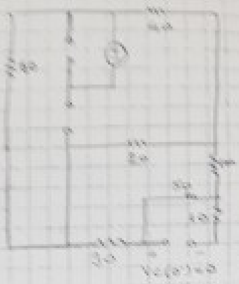


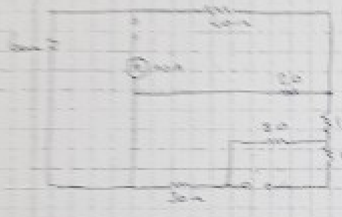
$$\begin{vmatrix} s+6+4 & -4 \\ 4 & 4+\frac{4}{s} \end{vmatrix} \cdot \begin{vmatrix} I_L(s) \\ I_c(s) \end{vmatrix} = \begin{vmatrix} 1+\frac{6}{s} \\ -\frac{6}{s}+\frac{6}{s} \end{vmatrix}$$

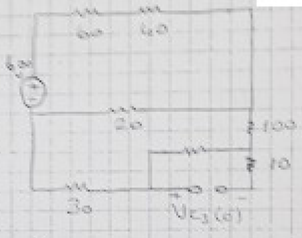
$$I_L(s)=\frac{\begin{vmatrix} 1+\frac{6}{s} & -4 \\ 0 & 4+\frac{4}{s} \end{vmatrix}}{\begin{vmatrix} s+10 & -4 \\ 4 & 4+\frac{4}{s} \end{vmatrix}} \qquad I_c(t)=\frac{\begin{vmatrix} s+10 & 1+\frac{6}{s} \\ 4 & 0 \end{vmatrix}}{\begin{vmatrix} s+10 & 4 \\ 4 & 4+\frac{4}{s} \end{vmatrix}}$$


40Ω
5A
10V
10V(t-1)A
20Ω
100Ω
200u(t)V
50Ω
10Ω
30Ω
Vc(t)
ic(t)
t≥0 için
Vc(t)=?
Ic(t)=?
1. Durum devresi
60Ω
10A
2Ω
Vc(0⁻)
ic(0⁻)
2. Durum devresi
I1(∞)
I2(∞)
Vc(∞)
Ic(∞)



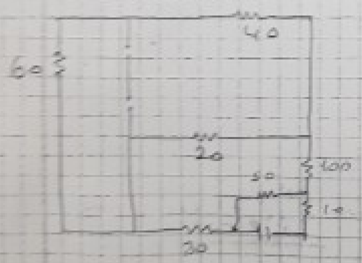






$$I_{50}(0^-) = \frac{600}{\frac{180 \times 20}{180+20} + 60 + 40} \times \frac{20}{20+100+50+30} = 0{,}51\ A$$

$$-V_{C_3}(0^-) + 10 \times 0 + 30 \times 0{,}51 = 0 \quad V_C(0^-) = -25{,}5 = V_{C_3}(0^+)$$



$$R_{eq} = \frac{\frac{(60+40).(20)}{(60+40)(20)} \times (30+50+100 \ldots}{\frac{(60+40).(20)}{60+40+20} + (30+50+100)} + \ldots$$

$$= 25{,}25\ \Omega$$

$$\tau = R_{eq} \times C = 25{,}25 \times 5 = 126{,}25\ \Omega$$

$$V_C(t) = A \cdot e^{-t/\tau} + V_C(\infty) = A \cdot e^{-t/126{,}25} + 42{,}5$$

$t = 0$ için $V_C(0^+)$

$$-25{,}5 = A \cdot 1 + 42{,}5 \Rightarrow A = -68$$

$v_c(t) = -68\,e^{-t/126,15} + 42,5$

$i_c(t) = C\,\frac{dv_c(t)}{dt} = 5\cdot(-68)\times\left(\frac{-1}{126,15}\right)e^{-t/126,15}$

$i_c(t) = 2,68\,e^{-t/126,15}$ A

Anahtar uzun süre kapalı kaldıktan sonra $t=0$ anında açılıyor. $t>0$ için $I_L(t)=?$ $V_L(t)=?$ $I_3(t)=?$

1. Durum devresi

$I_L(0^-) = \frac{11V}{\frac{3\times2}{3+2}+1}\times\frac{3}{3+2} = 3A$

$I_3(0^-) = \frac{11V}{\frac{3\times2}{3+2}+1}\times\frac{2}{3+2} = 2A$

2. Durum Devresi (2 orun sabiti 2 durum devresinde bulunur)

$I_L(\infty) = 15\cdot\frac{3}{3+2} = 9A$

$I_3(\infty) = 15\cdot\frac{2}{3+2} = 6A$

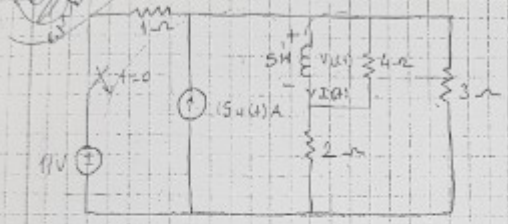
$R_{es} = \frac{(3+2)\times4}{3+2+4} = \frac{20}{9}\,\Omega$

$\tau = \frac{L}{R_{es}} = \frac{5}{\frac{20}{9}} = \frac{45}{20} = \frac{9}{4}$ sn

$v_c(t) = -68 \cdot e^{-t/126,15} + 42,5$

$i_c(t) = C \cdot \frac{dv_c(t)}{dt} = 5 \cdot (-68) \times \left(\frac{1}{126,15}\right) e^{-t/126,15}$

$i_c(t) = 2,68\, e^{-t/126,15}$ A

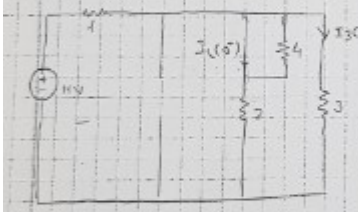


Anahtar uzun süre kapalı kaldıktan sonra $t=0$ anında açılıyor.

$t \geq 0$ için $I_L(t) = ?$

$V_L(t) = ?$ $I_3(t) = ?$

1. Durum devresi

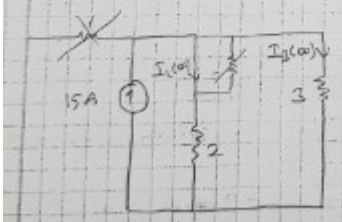


$I_L(0^-) = \frac{11V}{\frac{3\times2}{3+2}+1} \times \frac{3}{3+2} = 3A$

$I_3(0^-) = \frac{11V}{\frac{3\times2}{3+2}+1} \times \frac{2}{3+2} = 2A$

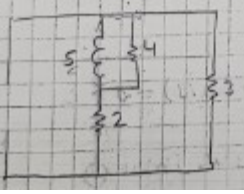
2. Durum Devresi

Zaman sabiti 2. durum devresinde bulunur



$I_L(\infty) = 15 \cdot \frac{3}{3+2} = 9A$

$I_3(\infty) = 15 \cdot \frac{2}{3+2} = 6A$



$\tau = \frac{L}{R_{es}} \Rightarrow R_{es} = \frac{(3+2)\times4}{3+2+4} = \frac{20}{9}\Omega$

$\tau = \frac{5}{\frac{20}{9}} = \frac{45}{20} = \frac{9}{4}$ s

$I_L(t) = A \cdot e^{-t/\tau} + I_L(\infty)$ ... (1)

$I_L(t) = A \cdot e^{-t/(5/6)} + 9$ $\quad t = 0$ için $I_L(0^+) = 3$

$3 = A \cdot 1 + 9 \Rightarrow A = -6$

$I_L(t) = -6\, e^{-6/5\, t} + 9$

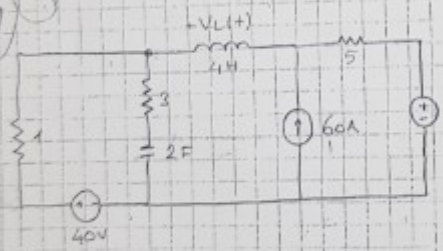
$V_L(t) = L \cdot \frac{di(t)}{dt} = 5 \cdot (-6) \cdot \left(-\frac{6}{5}\right) e^{-\frac{6}{5}t} = \frac{36}{3}\, e^{-1,2t}$

$I_{R_3}(t) = A \cdot e^{-t/\tau} + I_{R_3}(\infty) = A\, e^{-4/3\, t} + 6$

$t = 0$ için $I_{R_3}(0^+) = 2 \Rightarrow 2 = A + 6 \Rightarrow A = -4$

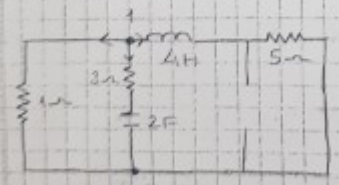
$I_{R_3}(t) = -4\, e^{-4/3\, t} + 6$

$V_{R_3}(t) = R_3 \cdot I_{R_3}(t) = 3\left[(-4)\, e^{-4/3\, t} + 6\right] = -12\, e^{-\frac{3}{4}t} + 18$



$I_L(t) = ?$

$V_L(t) = ?$



$\frac{1}{1} + \frac{1}{3 + \frac{1}{0,2}} + \frac{1}{0,4s + 5} = 0$

$= \frac{1}{1} + \frac{2s}{6s+1} + \frac{1}{4s+5} = 0$

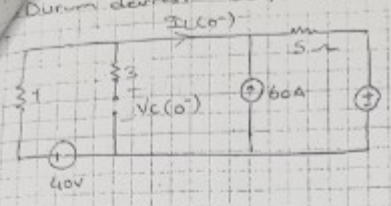
$24s^2 + 30s + 4s + 5 + 8s^2 + 10s + 6s + 1 =$

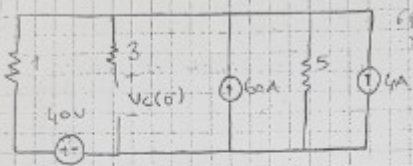
$32s^2 + 50s + 8 = 0 \Rightarrow 16s^2 + 25s + 3 = 0$

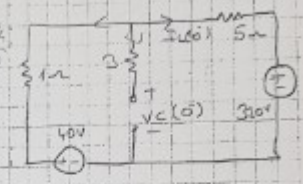
$\Delta = b^2 - 4ac \Rightarrow \Delta = 433$

$s_{1,2} = \frac{-25 \pm \sqrt{433}}{2 \times 16} \Rightarrow (s + 1,43)(s + 0,13) = 0$

Durum denklemi: self kısa devre, C açık devre



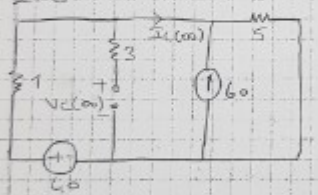


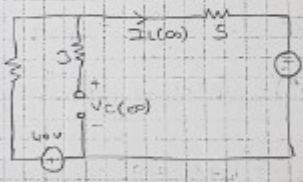


$I_L(0^-) = \frac{320-40}{6} = \frac{280}{6} = 46,66\ A$

$-V_C(0^-) + 1 \cdot (+46,66) + 40 = 0 \quad V_C(0^-) = -6,666\ V$

2. durum denklemi

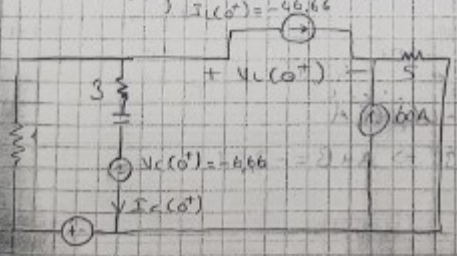


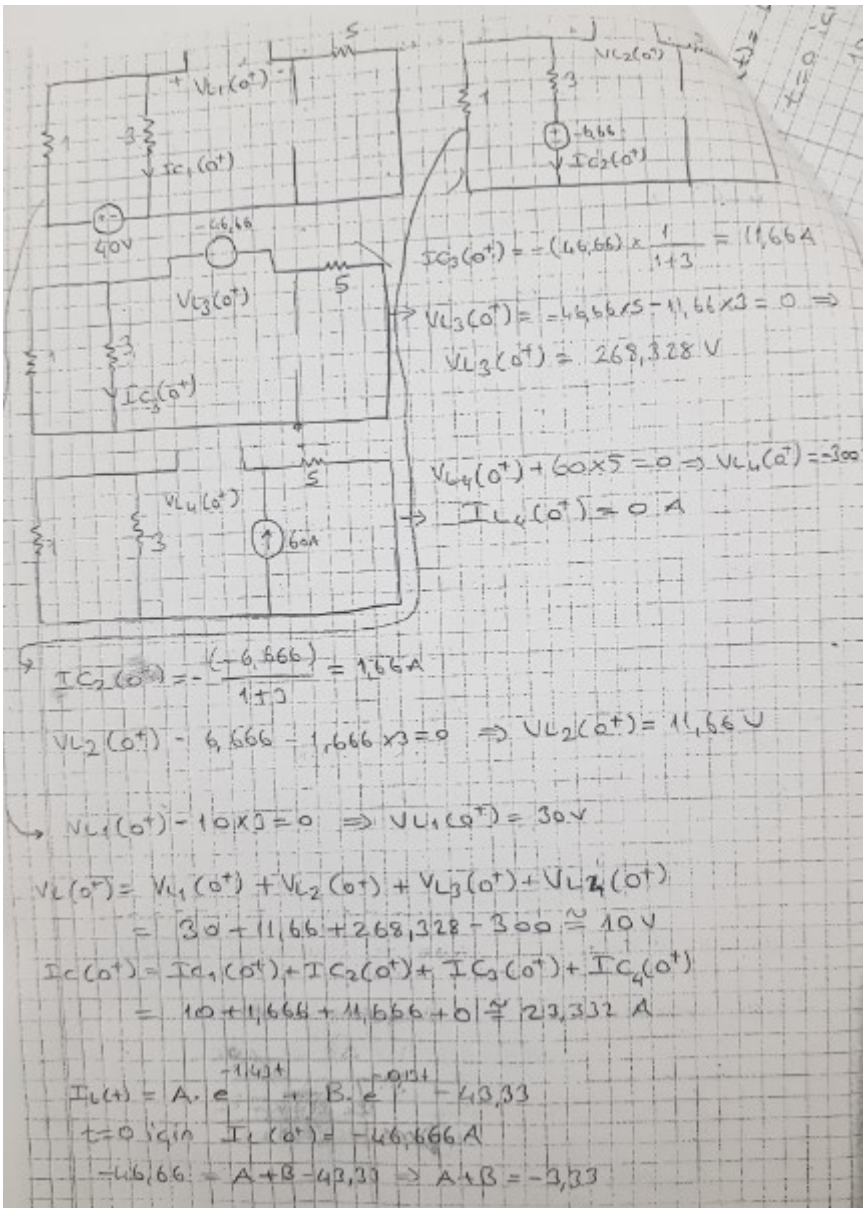


$I_L(\infty) = \frac{-300+40}{6} = \frac{-260}{6} = -43,33\ A$

$-V_C(\infty) + 1 \cdot (-43,33) + 40 \Rightarrow V_C(\infty) = -3,33\ V$

0+ anı eşdeğer devresi. 2. durumdan çizilir.





$I_{C3}(0^+) = -(46,66) \times \frac{1}{1+3} = 11,66\,A$

$\Rightarrow V_{L3}(0^+) = -46,66 \times 5 - 11,66 \times 3 = 0 \Rightarrow$

$V_{L3}(0^+) = 268,328\,V$

$V_{L4}(0^+) + 60 \times 5 = 0 \Rightarrow V_{L4}(0^+) = -300$

$\Rightarrow I_{L4}(0^+) = 0\,A$

$I_{C2}(0^+) = -\frac{(-6,666)}{1+3} = 1,66\,A$

$V_{L2}(0^+) - 6,666 - 1,666 \times 3 = 0 \Rightarrow V_{L2}(0^+) = 11,66\,V$

$V_{L1}(0^+) - 10 \times 3 = 0 \Rightarrow V_{L1}(0^+) = 30\,V$

$V_L(0^+) = V_{L1}(0^+) + V_{L2}(0^+) + V_{L3}(0^+) + V_{L4}(0^+)$

$= 30 + 11,66 + 268,328 - 300 \simeq 10\,V$

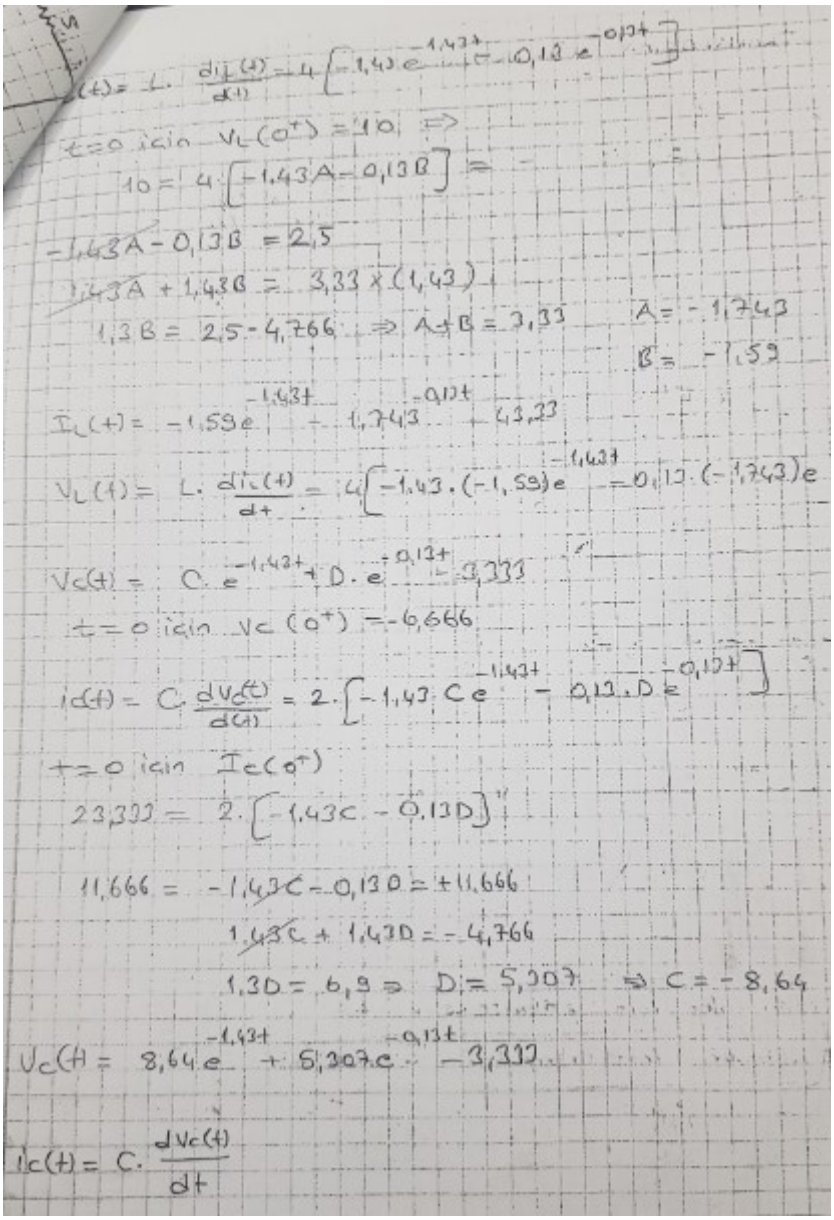
$I_C(0^+) = I_{C1}(0^+) + I_{C2}(0^+) + I_{C3}(0^+) + I_{C4}(0^+)$

$= 10 + 1,666 + 11,666 + 0 \simeq 23,332\,A$

$I_L(t) = A \cdot e^{-1/4 t} + B \cdot e^{-0,5 t} - 43,33$

$t=0$ için $I_L(0^+) = -46,666\,A$

$-46,66 = A + B - 43,33 \Rightarrow A + B = -3,33$



$V_L(t) = L \cdot \frac{di_L(t)}{dt} = 4\left[-1,43\,e^{-1,43t} - 0,13\,e^{-0,13t}\right]$

$t=0$ için $V_L(0^+) = 10 \Rightarrow$

$10 = 4\left[-1,43A - 0,13B\right] =$

$-1,43A - 0,13B = 2,5$

$1,43A + 1,43B = 3,33 \times (1,43)$

$1,3B = 2,5 - 4,766 \Rightarrow A+B = 3,33$ $\quad A = -1,743$

$B = -1,59$

$I_L(t) = -1,59\,e^{-1,43t} + 1,743\,e^{-0,13t} + 43,23$

$V_L(t) = L \cdot \frac{di_L(t)}{dt} = 4\left[-1,43 \cdot (-1,59)\,e^{-1,43t} - 0,13 \cdot (-1,743)\,e^{-1,43t}\right.$

$V_C(t) = C\,e^{-1,43t} + D \cdot e^{-0,13t} - 3,333$

$t=0$ için $V_C(0^+) = -6,666$

$i_C(t) = C \cdot \frac{dV_C(t)}{dt} = 2 \cdot \left[-1,43\,Ce^{-1,43t} - 0,13 \cdot De^{-0,13t}\right]$

$t=0$ için $I_C(0^+)$

$23,333 = 2 \cdot \left[-1,43C - 0,13D\right]$

$11,666 = -1,43C - 0,13D = +11,666$

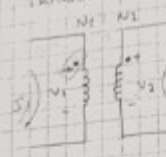
$1,43C + 1,43D = -4,766$

$1,3D = 6,9 \Rightarrow D = 5,307 \Rightarrow C = -8,64$

$V_C(t) = 8,64\,e^{-1,43t} + 5,307\,e^{-0,13t} - 3,333$

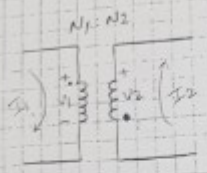
$i_C(t) = C \cdot \frac{dV_C(t)}{dt}$

TRANSFORMATÖRLÜ DEVRELERİN ÇÖZÜMÜ



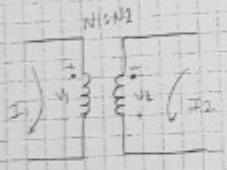
$$\frac{V_1}{V_2} = \frac{+N_1}{N_2}$$

$$\frac{I_1}{I_2} = -\left(\frac{-N_2}{N_1}\right) = \frac{N_2}{N_1}$$



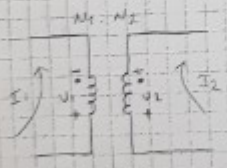
$$\frac{V_1}{V_2} = \frac{+N_1}{-N_2} = -\frac{N_1}{N_2}$$

$$\frac{I_1}{I_2} = -\left(\frac{+N_2}{N_1}\right) = -\frac{N_2}{N_1}$$



$$\frac{V_1}{V_2} = \frac{+N_1}{-N_2} = -\frac{N_1}{N_2}$$

$$\frac{I_1}{I_2} = -\left(\frac{+N_2}{N_1}\right) = -\frac{N_2}{N_1}$$



$$\frac{V_1}{V_2} = -\frac{N_1}{-N_2} = \frac{N_1}{N_2}$$

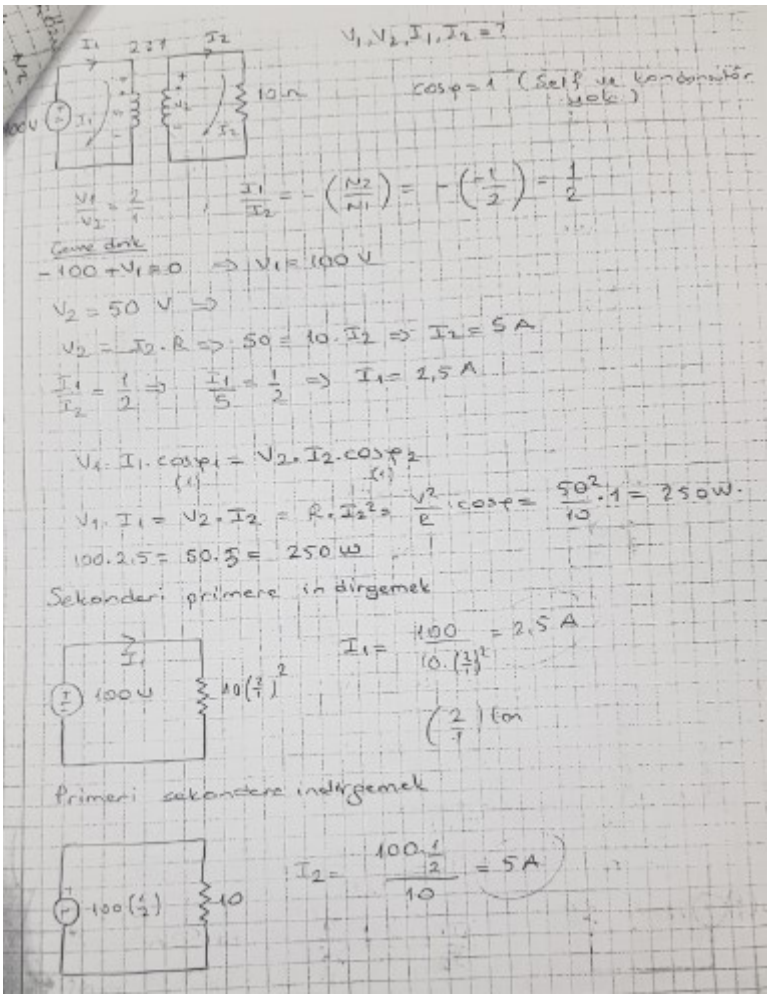
$$\frac{I_1}{I_2} = -\left(\frac{-N_2}{-N_1}\right) = -\frac{N_2}{N_1}$$

Gerilimler için polarite ve nokta
Akımlar için akım yönü ve nokta

$$\frac{V_1}{V_2} = \frac{?N_1}{?N_2}, \quad \frac{I_1}{I_2} = -\left(\frac{?N_2}{?N_1}\right)$$

Noktadan çıkış yapıyorsa −
Noktaya giriş ise +

Φ, H, B'ye çevir. daha sonra indirge



$V_1, V_2, I_1, I_2 = ?$

$\cos\varphi = 1$ (Self ve kondansatör yok)

$\frac{V_1}{V_2} = \frac{2}{1}$, $\frac{I_1}{I_2} = -\left(\frac{N_2}{N_1}\right) = -\left(\frac{1}{2}\right) = \frac{1}{2}$

Çevre denk

$-100 + V_1 = 0 \Rightarrow V_1 = 100\ V$

$V_2 = 50\ V \Rightarrow$

$V_2 = I_2 \cdot R \Rightarrow 50 = 10 \cdot I_2 \Rightarrow I_2 = 5\ A$

$\frac{I_1}{I_2} = \frac{1}{2} \Rightarrow \frac{I_1}{5} = \frac{1}{2} \Rightarrow I_1 = 2{,}5\ A$

$V_1 \cdot I_1 \cdot \cos\varphi_1 = V_2 \cdot I_2 \cdot \cos\varphi_2$

(1) (1)

$V_1 \cdot I_1 = V_2 \cdot I_2 = R \cdot I_2^2 \Rightarrow \frac{V^2}{R} \cdot \cos\varphi = \frac{50^2}{10} \cdot 1 = 250\ W$

$100 \cdot 2{,}5 = 50 \cdot 5 = 250\ W$

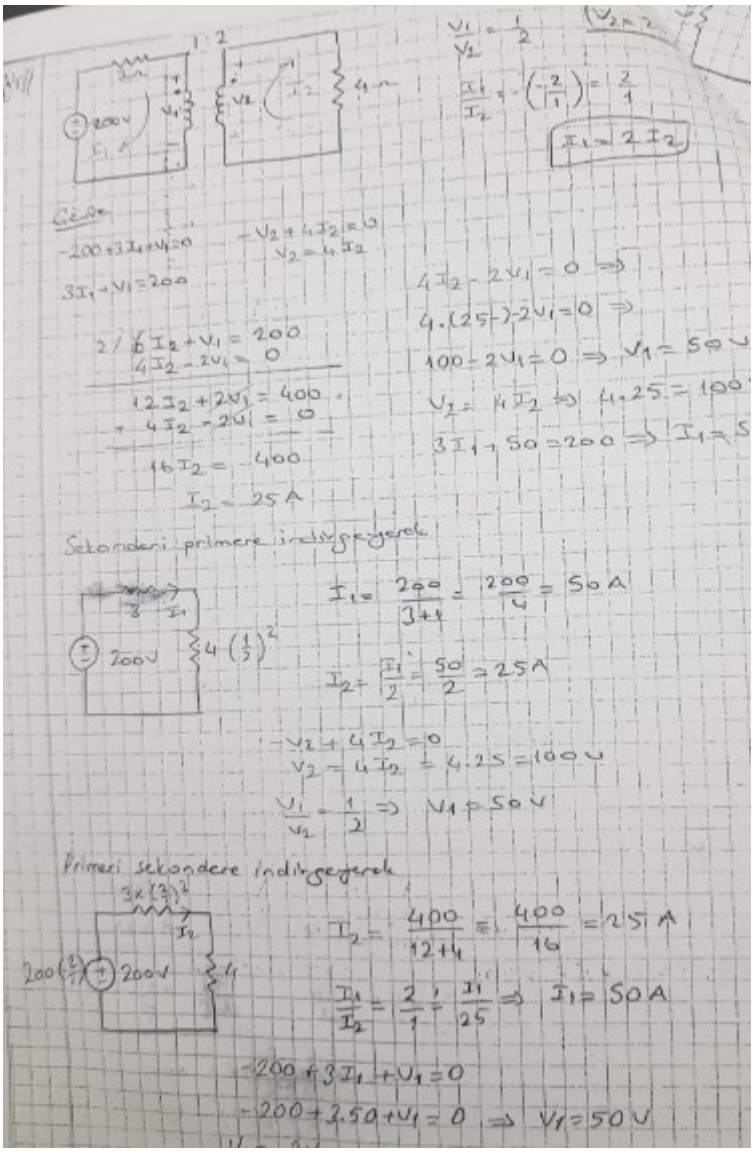
Sekonderi primere indirgemek

$I_1 = \frac{100}{10 \cdot \left(\frac{2}{1}\right)^2} = 2{,}5\ A$

$\left(\frac{2}{1}\right)$ Ton

Primeri sekondere indirgemek

$I_2 = \frac{100 \cdot \frac{1}{2}}{10} = 5\ A$



$\frac{V_1}{V_2} = \frac{1}{2}$

$\frac{I_1}{I_2} = -\left(\frac{-2}{1}\right) = \frac{2}{1}$

$I_1 = 2I_2$

Çözüm

$-200 + 3I_1 + V_1 = 0$

$3I_1 + V_1 = 200$

$-V_2 + 4I_2 = 0$

$V_2 = 4I_2$

$2/\ 6I_2 + V_1 = 200$

$4I_2 - 2V_1 = 0$

$12I_2 + 2V_1 = 400$

$+\ 4I_2 - 2V_1 = 0$

$16I_2 = 400$

$I_2 = 25A$

$4I_2 - 2V_1 = 0 \Rightarrow$

$4 \cdot (25) - 2V_1 = 0 \Rightarrow$

$100 - 2V_1 = 0 \Rightarrow V_1 = 50V$

$V_2 = 4I_2 \Rightarrow 4 \cdot 25 = 100$

$3I_1 + 50 = 200 \Rightarrow I_1 = 5$

Sekonderi primere indirgeyerek

$I_1 = \frac{200}{3+1} = \frac{200}{4} = 50A$

$I_2 = \frac{I_1}{2} = \frac{50}{2} = 25A$

$-V_2 + 4I_2 = 0$

$V_2 = 4I_2 = 4 \cdot 25 = 100V$

$\frac{V_1}{V_2} = \frac{1}{2} \Rightarrow V_1 = 50V$

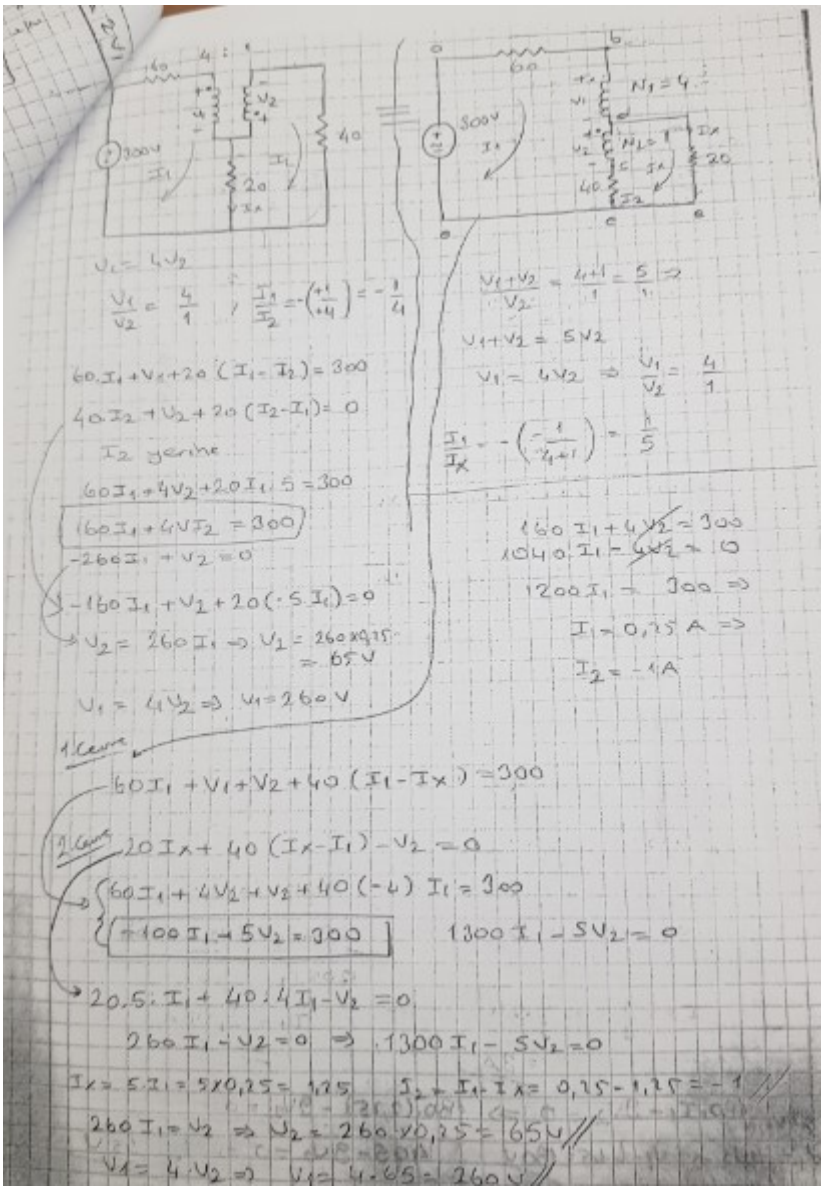
Primeri sekondere indirgeyerek

$I_2 = \frac{400}{12+4} = \frac{400}{16} = 25A$

$\frac{I_1}{I_2} = \frac{2}{1} = \frac{I_1}{25} \Rightarrow I_1 = 50A$

$-200 + 3I_1 + V_1 = 0$

$-200 + 3 \cdot 50 + V_1 = 0 \Rightarrow V_1 = 50V$



$V_1 = 4V_2$

$\frac{V_1}{V_2} = \frac{4}{1}$ / $\frac{I_1}{I_2} = -\left(\frac{+1}{+4}\right) = -\frac{1}{4}$

$60I_1 + V_1 + 20(I_1 - I_2) = 300$

$40I_2 + V_2 + 20(I_2 - I_1) = 0$

I_2 yerine

$60I_1 + 4V_2 + 20I_1 - 5 = 300$

$160I_1 + 4V_2 = 300$

$-260I_1 + V_2 = 0$

$-160I_1 + V_2 + 20(-5I_1) = 0$

$V_2 = 260I_1 \Rightarrow V_1 = 260 \times 0{,}25 = 65V$

$V_1 = 4V_2 \Rightarrow V_1 = 260V$

1.Çevre

$60I_1 + V_1 + V_2 + 40(I_1 - I_x) = 300$

2.Çevre

$20I_x + 40(I_x - I_1) - V_2 = 0$

$60I_1 + 4V_2 + V_2 + 40(-4)I_1 = 300$

$-100I_1 + 5V_2 = 300$

$1300I_1 - 5V_2 = 0$

$20{,}5 \cdot I_1 + 40 \cdot 4I_1 - V_2 = 0$

$260I_1 - V_2 = 0 \Rightarrow 1300I_1 - 5V_2 = 0$

$I_x = 5I_1 = 5 \times 0{,}25 = 1{,}25$ $I_2 = I_1 - I_x = 0{,}25 - 1{,}25 = -1$

$260I_1 = V_2 \Rightarrow V_2 = 260 \times 0{,}25 = 65V$

$V_1 = 4V_2 \Rightarrow V_1 = 4 \cdot 65 = 260V$

$\frac{V_1 + V_2}{V_2} = \frac{4+1}{1} = \frac{5}{1} \Rightarrow$

$V_1 + V_2 = 5V_2$

$V_1 = 4V_2 \Rightarrow \frac{V_1}{V_2} = \frac{4}{1}$

$\frac{I_1}{I_x} = -\left(\frac{1}{-4+1}\right) = \frac{1}{5}$

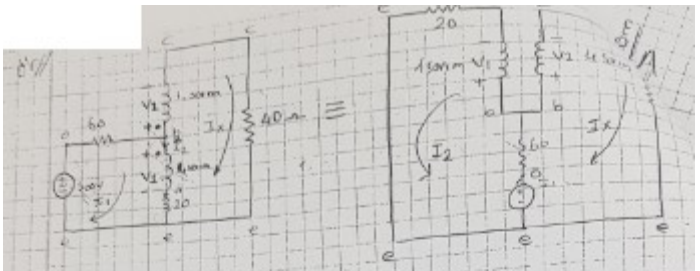
$160I_1 + 4V_2 = 300$

$1040I_1 - 4V_2 = 0$

$1200I_1 = 300 \Rightarrow$

$I_1 = 0{,}25A \Rightarrow$

$I_2 = -1A$



$\frac{V_1}{V_1+V_2} = \frac{4}{4+1}$ $\quad 5V_1 = 4V_1 + 4V_2$ $\quad V_1 = 4V_2$

$\frac{-1}{I_x} = -\left(\frac{-4+1}{4}\right) = \frac{3}{4} \Rightarrow 3I_x = 4I_1$ $\quad I_x = \left(\frac{4}{3} I_1\right)$

1 Cuve

$60I_1 + V_1 + 20(I_1 - I_2) = 300$

$60I_1 + V_1 + 20I_1 - 20I_x = 300$

2 Cuve

$-V_2 + 40I_x + 20(I_x - I_1) - V_1 = 0$

$60I_1 + V_2 + 20\left(I_1 - \frac{4}{3}I_1\right) = 200$

$180I_1 + 12V_2 - 20I_1 = 300$

$160I_1 + 12V_2 = 300$

$V_2 + 40 \cdot \frac{4}{3} I_1 + 20\left(\frac{4}{3}I_1 - I_1\right) - 4V_2 = 0$

$3V_2 + 160I_1 + 20I_1 - 12V_2 = 0$

$180I_1 - 9V_2 = 0 \quad / 4 = 720I_1 - 36V_2 = 0$

$160I_1 + 12V_2 = 300 \quad / 3 + 480I_1 + 36V_2 = 2700$

$1200I_1 = 2700 \Rightarrow$

$I_1 = 2{,}25\ A$

$I_x = \frac{3}{4} I_1 \Rightarrow \frac{4}{3} \cdot (2{,}25)$

$= 3A$

$180 \cdot I_1 - 9V_2 = 0 \Rightarrow 180 \cdot (2{,}25) - 9V_2 = 0$

$V_1 = 4V_2 \Rightarrow V_1 = 4 \cdot 45 = 180V$ $\quad 405 - 9V_2 = 0 \Rightarrow V_2 = 45V$

$\frac{V_1}{V_2} = \frac{4}{1} \Rightarrow \quad V_1 = 4V_2$

$\frac{I_2}{I_x} = -\left(\frac{1}{4}\right) = -\frac{1}{4} \Rightarrow I_x = -4I_2$

$V_1 + 20I_2 - 300 + 60(I_2 + I_x) = 0$

$4V_2 + 20I_2 - 180I_2 = 300 \Rightarrow$

$4V_2 - 160I_2 = 300$

$V_2 + 40I_x - 300 + 60(I_x + I_2) = 0$ ($I_x = -4I_2$)

$V_2 + 40 \cdot (-4I_2) - 300 = 240I_2 + 60I_2 = 0$

$V_2 + 40(-4)I_2 - 180I_2 = 300$

$V_2 - 340I_2 = 300$

$-4V_2 + 1360I_2 = -1200$

$4V_2 - 160I_2 = 300$

$1200I_2 = -900 \Rightarrow I_2 = -0{,}75$

$I_x = -4I_2 \Rightarrow$

$I_x = -4(-0{,}75) = 3A$

$I_1 = I_x + (I_2) = 3 - 0{,}75 = 2{,}25$ A

$V_2 - 340(-0{,}75) = 300 \Rightarrow V_2 = 45$ V

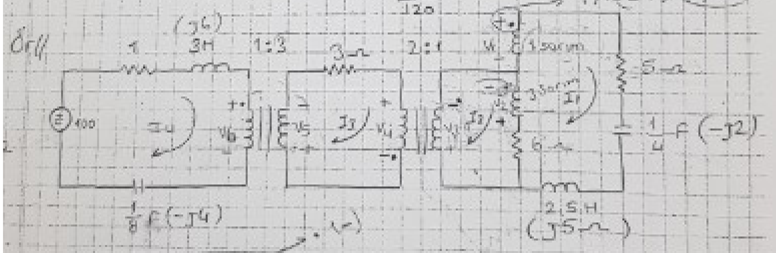
$V_1 = 4V_2 \Rightarrow V_1 = 180$ V

$C \rightarrow F \rightarrow X_C = \frac{1}{jwc}$

$L \rightarrow H \rightarrow X_L = jwL$

$R = \ldots$

Ör//



$\frac{V_1 + V_2}{V_2} = \frac{1-3}{-3} = \frac{2}{3}$

$\frac{I_1}{I_2} = -\left(\frac{3}{-3+1}\right) = -\frac{3}{4}$

$\frac{V_3}{V_4} = \frac{-1}{-2} = \frac{1}{2}$

$\frac{V_3}{V_4} = \frac{N_3}{N_4} \Rightarrow$ Normalde

ama V_3'ün (−)'si noktayı V_4' noktayı görürse

$\frac{V_3}{V_4} = \frac{-N_3}{-N_4}$ olur

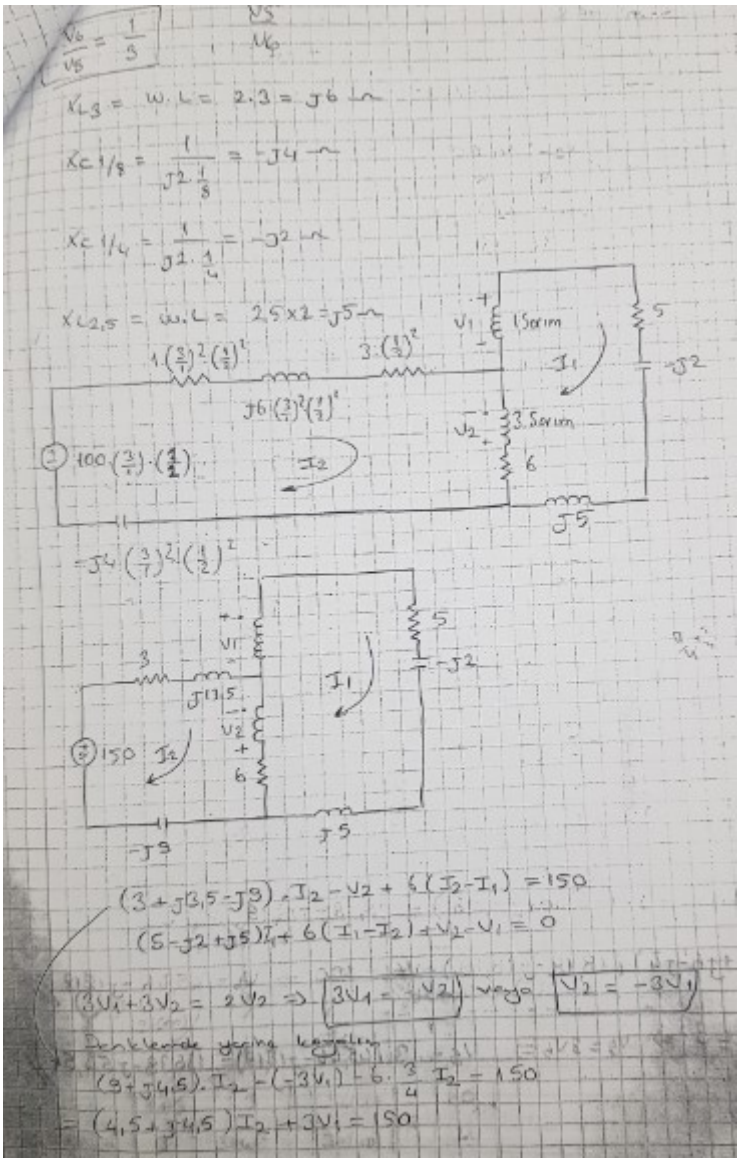
$\frac{V_0}{V_S} = \frac{1}{3}$

$X_{L3} = w.L = 2.3 = j6\ \Omega$

$X_{C\,1/8} = \frac{1}{j2.\frac{1}{8}} = -j4\ \Omega$

$X_{C\,1/4} = \frac{1}{j2.\frac{1}{4}} = -j2\ \Omega$

$X_{L2,5} = w.L = 2,5 \times 2 = j5\ \Omega$



$(3 + j13,5 - j9).I_2 - V_2 + 6(I_2 - I_1) = 150$

$(5 - j2 + j5)I_1 + 6(I_1 - I_2) + V_2 - V_1 = 0$

$3V_1 + 3V_2 = 2V_2 \Rightarrow \boxed{3V_1 = -V_2}$ veya $\boxed{V_2 = -3V_1}$

Denklemde yerine koyarsak

$(9 + j4,5).I_2 - (-3V_1) - 6.\frac{3}{4}I_2 = 150$

$(4,5 + j4,5)I_2 + 3V_1 = 150$

$(5-j2+j5)\cdot\frac{3}{4}\cdot I_2 + 6\cdot\left(\frac{3}{4}I_2 - I_2\right) - 8V_1 - V_1 = 0$

$= \left(\frac{13+j9-6}{4}\right) I_2 - 4V_1 = 0$

$= \left(\frac{9+j3}{4}\right) I_2 - 4V_1 = 0$

$-2 / = (2,25 + j2,25) I_2 - 4V_1 = 0$

$3V_1 + 8V_1 = 150 \Rightarrow 11V_1 = 150, \quad V_1 = 13,63$ //

$V_2 = -40,89$ //

$(4,5+j4,5) I_2 = 150 \cdot \frac{3 \times 150}{4} \Rightarrow$

$I_2 = \frac{1650 - 450}{11 \cdot (4,5+j4,5)} \Rightarrow \frac{1200}{11(4,5+j4,5)} = 12,12 - j12,12$ //

$I_1 = \frac{3}{4} \cdot I_2 = 9,09 - j12,12$ //

$\frac{I_3}{I_2} = -\left(\frac{-1}{-2}\right) = -\frac{1}{2} \Rightarrow I_3 = -1/2\ I_2$ //

$\frac{I_4}{I_2} = -\left(\frac{3}{1}\right) = -\frac{3}{1} \Rightarrow I_4 = -3\ I_3$ //

$I_3 = -\frac{1}{2} I_2 \Rightarrow$

$I_3 = -\frac{1}{2}(12,12 - j12,12) = -6,06 + j6,06$ //

$I_4 = -3(-6,06 + j6,06) = 18,18 - j18,18$ //

$(1+j6-j4)(18,18 - j18,18) + V_6 = 100 \Rightarrow V_6 = 45,46 - j18,18$ //

$\frac{V_5}{V_6} = 3 \Rightarrow V_5 = 3V_6 \Rightarrow V_5 = 3 \cdot (45,46 - j18,18) = 136,38 - j54,54$ //

$V_5 + 3(-6,06 + j6,06) - V_4 = 0 \Rightarrow$

$V_4 = 136,38 - j54,54 + 3(-6,06 + j6,06) = 0$

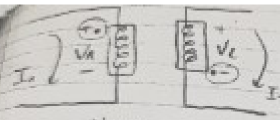
$V_4 = -3(-6,06 + j6,06) - 136,38 + j54,54$

$= 18,18 - j6,06 - (136,38 + j54,54)$

$= -118,2 + j36,36$ //

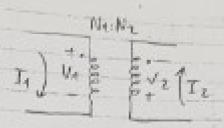
$\frac{V_3}{V_4} = \frac{-1}{-2} = \frac{1}{2} \Rightarrow V_3 = \frac{1}{2} V_4 \Rightarrow$

$V_3 = \frac{1}{2}(-118,2 + j36,36) = -53,1 + j18,18$ //



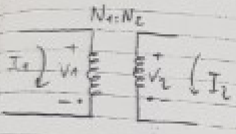
$\frac{V_1}{V_2} = -\frac{N_1}{N_2}$

$\frac{I_1}{I_2} = -\frac{N_2}{N_1}$



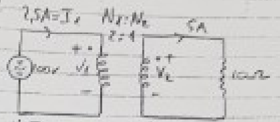
$\frac{V_1}{V_2} = -\frac{N_1}{N_2}$

$\frac{I_1}{I_2} = +\frac{N_2}{N_1}$



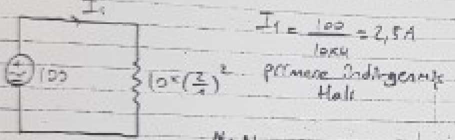
$\frac{V_1}{V_2} = +\frac{N_1}{N_2}$

$\frac{I_1}{I_2} = -\frac{N_2}{N_1}$



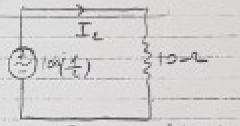
$V_1 I_1 = 100 \times 2{,}5 = V_2 I_2 = 50 \times 5 = 250W$

$\frac{V_1}{V_2} = \frac{N_1}{N_2}$, $R_L I_2^2 = 10 \times 5^2 = 250W$, $V_2 = 50V$, $\frac{I_1}{I_2} = \frac{N_2}{N_1} = \frac{1}{2}$, $I_1 = 2{,}5A$.

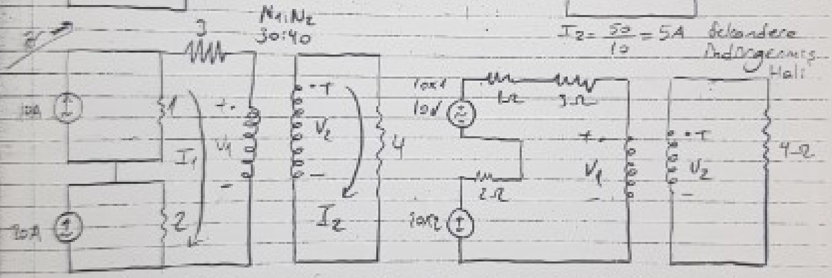


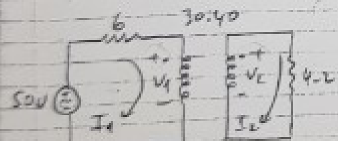
$I_1 = \frac{100}{10 \times 4} = 2{,}5A$

primere İndirgenmiş Hali



$I_2 = \frac{50}{10} = 5A$ Sekondere İndirgenmiş Hali





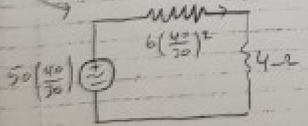
$\frac{V_1}{V_2} = \frac{30}{40}$, $V_2 = \frac{4}{3}V_1$, $\frac{I_1}{I_2} = \frac{40}{30} \Rightarrow I_2 = \frac{3}{4} I_1$

$-50 + 6I_1 + V_1 = 0$, $-V_2 + 4 \cdot I_2 = 0 \Rightarrow$

$6I_1 + V_1 = 50 \Rightarrow -\frac{4}{3}V_1 + 4 \cdot \frac{3}{4} I_1 = 0$

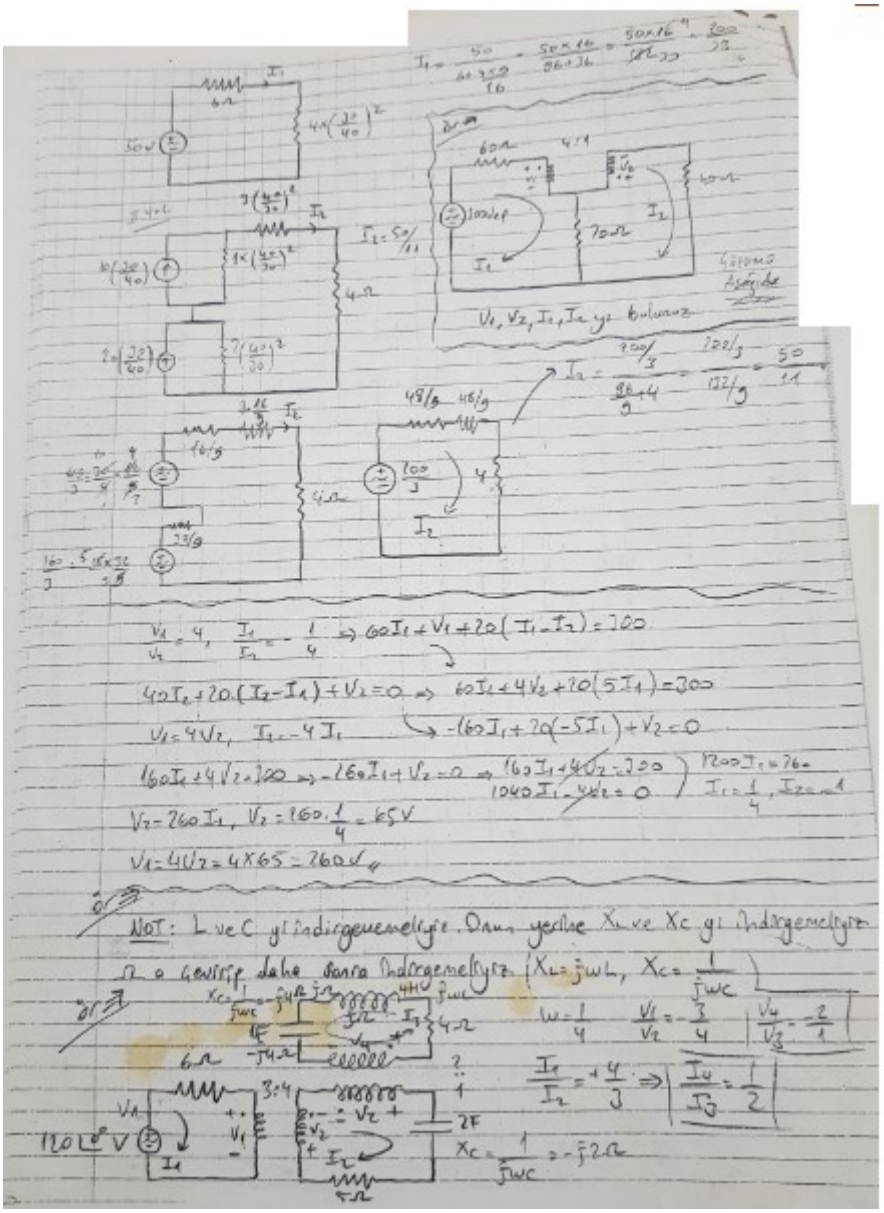
$6I_1 + V_1 = 50$, $3I_1 - \frac{4V_1}{3} = 0 \Rightarrow \frac{11V_1}{3} = 50 \Rightarrow V_1 = 150/11$, $V_2 = \frac{4}{3}V_1 = \frac{200}{11}$

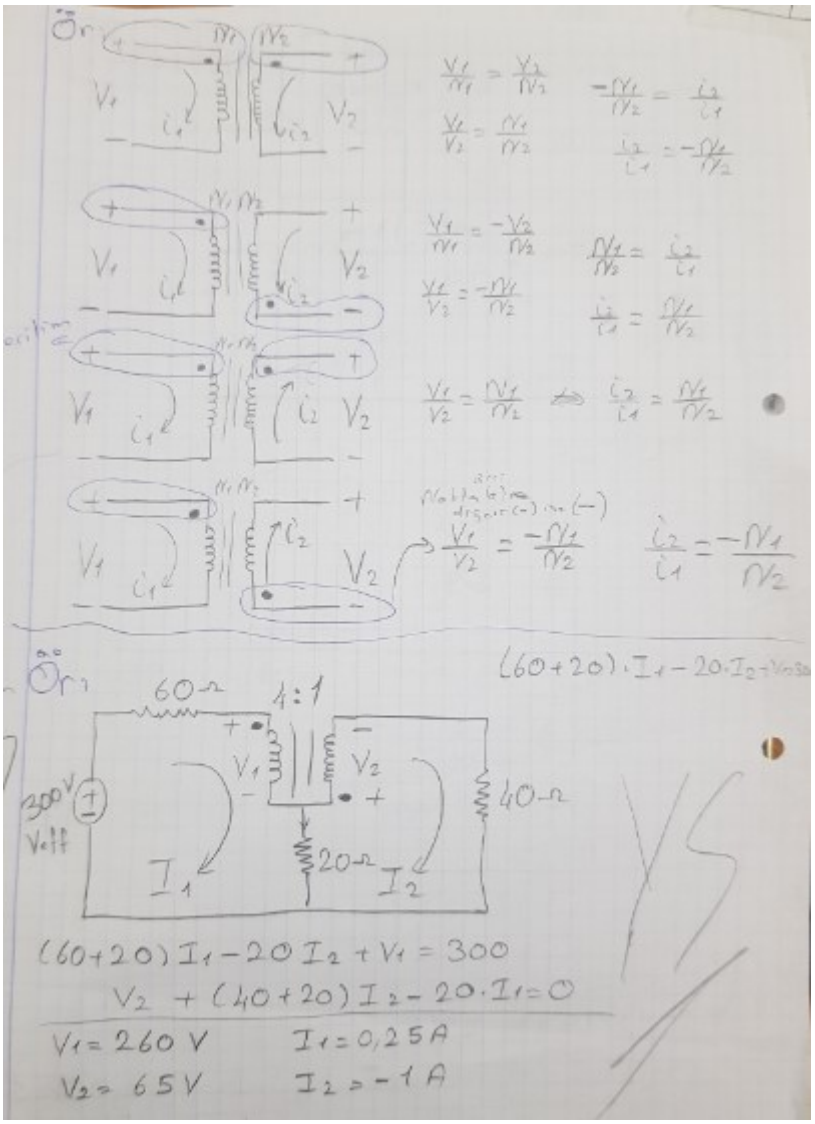
$-\frac{200}{11} + 4I_2 = 0 \Rightarrow 4I_2 = \frac{200}{11} \Rightarrow I_2 = \frac{50}{11}$ → I_1



$I_2 = \frac{200/3}{\frac{96}{9}+4} = \frac{200/3}{\frac{32}{3}+4} = \frac{200/3}{\frac{32+12}{3}} = \frac{200}{44} = \frac{50}{11}$

$I_1 = \frac{4}{3} I_2 = \frac{4}{3} \cdot \frac{50}{11} = \frac{200}{33}$


$I_1 = \frac{50}{4+\frac{200}{10}} = \frac{50\times10}{60} = \frac{500}{60} = \frac{25}{3}$
50V
6Ω
4Ω
I_1
I_2
$I_2 = \frac{50}{11}$
60Ω
4:1
40Ω
70Ω
100V
V_1, V_2, I_1, I_2 yi bulunuz
Gözüm Aşağıda
$\frac{700}{3}$
$\frac{122}{3}$
$\frac{50}{11}$
$\frac{48}{3}$
$\frac{46}{3}$
$\frac{700}{3}$
$\frac{23}{3}$
$\frac{160}{3}$
$\frac{V_1}{V_2} = 4$, $\frac{I_1}{I_2} = -\frac{1}{4}$ $\Rightarrow$ $60I_1 + V_1 + 20(I_1 - I_2) = 100$
$40I_2 + 20(I_2 - I_1) + V_2 = 0$ $\Rightarrow$ $60I_1 + 4V_2 + 20(5I_1) = 300$
$V_1 = 4V_2$, $I_2 = -4I_1$ $\rightarrow$ $-(60I_1 + 20(-5I_1)) + V_2 = 0$
$160I_1 + 4V_2 = 300$ $\Rightarrow$ $-160I_1 + V_2 = 0$ $\Rightarrow$ $160I_1 + 4V_2 = 300$
$160I_1 - 4V_2 = 0$
$320I_1 = 160$
$I_1 = \frac{1}{4}$, $I_2 = -1$
$V_2 = 160I_1$, $V_2 = 160 \cdot \frac{1}{4} = 65V$
$V_1 = 4V_2 = 4 \times 65 = 260V$
NOT: L ve C yi indirgeyemeliyiz. Daha sonra X_L ve X_C yi indirgemeliyiz.
Ω a geçtiğinde daha sonra indirgeyemeliyiz. ($X_L = j\omega L$, $X_C = \frac{1}{j\omega C}$)
$X_C = \frac{1}{j\omega C} = -j4\Omega$
$j4\Omega$
$4H$
$\frac{1}{4}F$
$-j4\Omega$
6Ω
4Ω
$\omega = 1$
$\frac{V_1}{V_2} = -\frac{3}{4}$
$\frac{V_4}{V_3} = -\frac{2}{1}$
$\frac{I_4}{I_2} = +\frac{4}{3} \Rightarrow \frac{I_4}{I_3} = \frac{1}{2}$
$120\angle 0^\circ V$
3:4
V_1
V_2
I_1
I_2
2F
$X_C = \frac{1}{j\omega C} = -j2\Omega$
4Ω



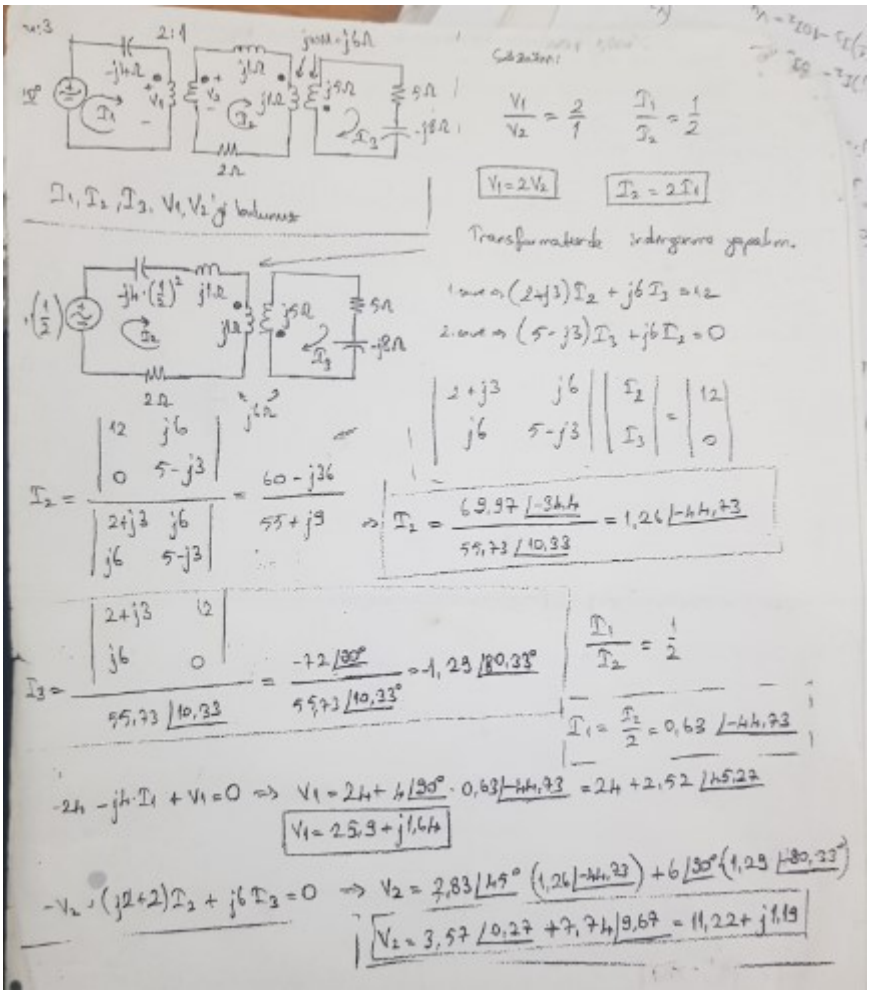
Örn

$(60+20)\,I_1 - 20\,I_2 + V_1 = 300$

$V_2 + (40+20)\,I_2 - 20\cdot I_1 = 0$

$V_1 = 260\ V \qquad I_1 = 0{,}25\ A$

$V_2 = 65\ V \qquad I_2 = -1\ A$



Sabemos:

$\frac{V_1}{V_2} = \frac{2}{1}$ $\quad \frac{I_1}{I_2} = \frac{1}{2}$

$V_1 = 2V_2$ $\quad I_2 = 2I_1$

I_1, I_2, I_3, V_1, V_2'yi bulunuz

Transformatörde indirgeme yapalım.

1. mesh $\Rightarrow (2+j3)I_2 + j6I_3 = 12$

2. mesh $\Rightarrow (5-j3)I_3 + j6I_2 = 0$

$$\begin{vmatrix} 2+j3 & j6 \\ j6 & 5-j3 \end{vmatrix} \begin{vmatrix} I_2 \\ I_3 \end{vmatrix} = \begin{vmatrix} 12 \\ 0 \end{vmatrix}$$

$$I_2 = \frac{\begin{vmatrix} 12 & j6 \\ 0 & 5-j3 \end{vmatrix}}{\begin{vmatrix} 2+j3 & j6 \\ j6 & 5-j3 \end{vmatrix}} = \frac{60-j36}{55+j9} \Rightarrow I_2 = \frac{69,97\angle -31,4}{55,73\angle 10,33} = 1,26\angle -41,73$$

$$I_3 = \frac{\begin{vmatrix} 2+j3 & 12 \\ j6 & 0 \end{vmatrix}}{55,73\angle 10,33} = \frac{-72\angle 90°}{55,73\angle 10,33°} = 1,29\angle 80,33°$$

$\frac{I_1}{I_2} = \frac{1}{2}$

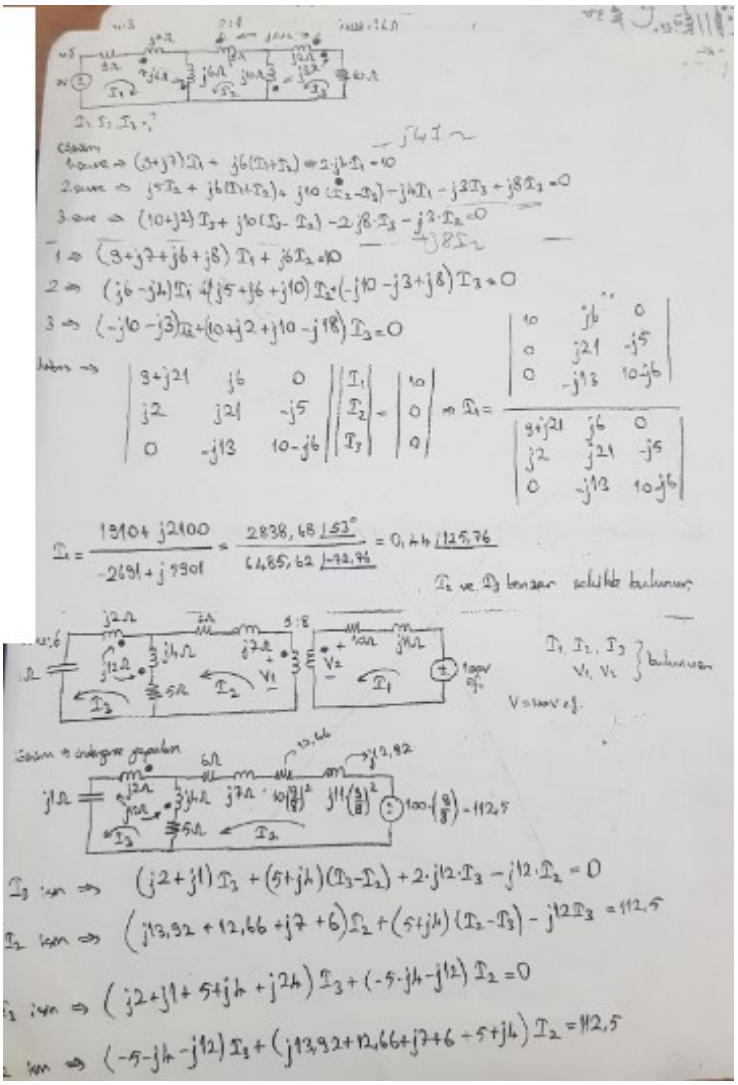
$I_1 = \frac{I_2}{2} = 0,63\angle -41,73$

$-24 - j4 \cdot I_1 + V_1 = 0 \Rightarrow V_1 = 24 + 4\angle 90° \cdot 0,63\angle -41,73 = 24 + 2,52\angle 45,27$

$V_1 = 25,9 + j1,64$

$-V_2 + (j2+2)I_2 + j6I_3 = 0 \Rightarrow V_2 = 2,83\angle 45° \left(1,26\angle -41,73\right) + 6\angle 90° \left(1,29\angle 80,33°\right)$

$V_2 = 3,57\angle 0,27 + 7,74\angle 9,67 = 11,22 + j1,19$



$I_1, I_2, I_3 = ?$

Çözüm:

1.eşitlik $\Rightarrow (3+j7)I_1 + j6(I_1+I_2) = 2 \cdot j4 \cdot I_1 + 10$

2.eşitlik $\Rightarrow j5 I_2 + j6(I_1+I_2) + j10(I_2-I_3) - j4I_1 - j3I_3 + j8I_2 = 0$

3.eşitlik $\Rightarrow (10+j2)I_3 + j10(I_3-I_2) - 2 \cdot j8 \cdot I_3 - j3 \cdot I_2 = 0$

$1 \Rightarrow (3+j7+j6+j8)I_1 + j6I_2 = 10$

$2 \Rightarrow (j6-j4)I_1 + (j5+j6+j10)I_2 + (-j10-j3+j8)I_3 = 0$

$3 \Rightarrow (-j10-j3)I_2 + (10+j2+j10-j16)I_3 = 0$

Matris $\Rightarrow$

$$\begin{vmatrix} 3+j21 & j6 & 0 \\ j2 & j21 & -j5 \\ 0 & -j13 & 10-j6 \end{vmatrix} \begin{vmatrix} I_1 \\ I_2 \\ I_3 \end{vmatrix} = \begin{vmatrix} 10 \\ 0 \\ 0 \end{vmatrix} \Rightarrow I_1 = \frac{\begin{vmatrix} 10 & j6 & 0 \\ 0 & j21 & -j5 \\ 0 & -j13 & 10-j6 \end{vmatrix}}{\begin{vmatrix} 3+j21 & j6 & 0 \\ j2 & j21 & -j5 \\ 0 & -j13 & 10-j6 \end{vmatrix}}$$

$$I_1 = \frac{13104 + j2100}{-2691 + j9901} = \frac{2838,68 \angle 52^\circ}{6485,62 \angle 97,94} = 0,44 \angle 125,76$$

I_2 ve I_3 benzer şekilde bulunur.

I_1, I_2, I_3 } bulunur
V_1, V_2 }

$V = 100 \angle 0^\circ$

Çözüm = ardışık gösterim

I_3 için $\Rightarrow (j2+j1)I_3 + (5+j4)(I_3-I_2) + 2 \cdot j12 \cdot I_3 - j12 \cdot I_2 = 0$

I_2 için $\Rightarrow (j13,92 + 12,66 + j7 + 6)I_2 + (5+j4)(I_2-I_3) - j12I_3 = 112,5$

I_3 için $\Rightarrow (j2+j1+5+j4+j24)I_3 + (-5-j4-j12)I_2 = 0$

I_2 için $\Rightarrow (-5-j4-j12)I_3 + (j13,92+12,66+j7+6+5+j4)I_2 = 112,5$

Matrisle: $\begin{vmatrix} -5-j16 & j31+5 \\ 18,66+j24,92 & -5-j16 \end{vmatrix} \begin{vmatrix} I_1 \\ I_2 \end{vmatrix} = \begin{vmatrix} 0 \\ 112,5 \end{vmatrix}$

$I_2 = \dfrac{\begin{vmatrix} 0 & 5+j31 \\ 112,5 & -5-j16 \end{vmatrix}}{\begin{vmatrix} -5-j16 & 5+j31 \\ 18,66+j24,92 & -5-j16 \end{vmatrix}} = \dfrac{562,5 \angle 31,87}{448,22 - j548,06} = \dfrac{3532,47 \angle 89,32}{704,14 \angle -56,07} = 5,017 \angle 145,83$

I_2 bunu istiyoruz

$\dfrac{I_1}{I_2} = \dfrac{3}{8}$ $\dfrac{V_1}{V_2} = \dfrac{3}{8}$

$V_1 = \dfrac{3V_2}{8} = 206,84 \angle -0,49$

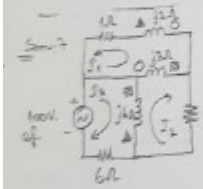
$I_1 = 5,64 \angle 145,83$

$-100 + (j11+10)\cdot I_1 + V_2 = 0$

$V_2 = 100 - (14,87 \angle 53,03)(5,64 \angle 145,83)$

$V_2 = 100 - 83,87 \angle 198,92 = 100 + 83,86 - j1,42$

$V_2 = 183,86 - j1,42 = 183,86 \angle -0,43$



$\Delta = j24\Omega$
$\circ = j15\Omega$
$\square = j5\Omega$

1. eşitlik $\Rightarrow (1+j2)I_1 + j3(I_1+I_2) + 2\cdot j15 I_1 + j15 I_2 + j5 I_3 + j5 I_2 + j25 I_3 - j25 I_2 = 0$

2. eşitlik $\Rightarrow 15 I_2 + j3(I_2+I_1) + j4(I_2-I_3) - j25 I_1 + 2\cdot j5 I_2 + j5\cdot I_1 - j5\cdot I_2 + j15 I_1 = 0$

3. eşitlik $\Rightarrow 6 I_3 + j4(I_3-I_2) - j5 I_3 + j25 I_1 - j5 I_1 = 100$

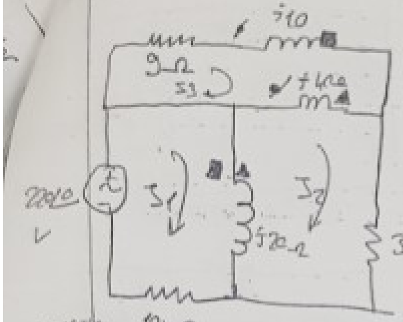
$1 \Rightarrow (1+j2+j3+j30)I_1 + (j3+j5+j5-j25)I_2 + (j25-j5)I_3 = 0$

$2 \Rightarrow (j3-j25+j5+j15)I_1 + (15+j3+j4+j10)I_2 + (-j4-j5)I_3 = 0$

$3 \Rightarrow (j25-j5)I_1 + (-j4-j5)I_2 + (6+j4)I_3 = 100$

Matrisle:

$\begin{vmatrix} 1+j35 & -j2 & j20 \\ -j2 & j17+15 & -j9 \\ j20 & -j9 & 6+j4 \end{vmatrix} \begin{vmatrix} I_1 \\ I_2 \\ I_3 \end{vmatrix} = \begin{vmatrix} 0 \\ 0 \\ 100 \end{vmatrix}$



Aynı noktaları farklı çevreler için dikkate alma

1.çevrede 2 özgü yük
1.çevrede 2 özgü yük (alma)
1.çevrede ve 2.çevrede özgü karşı
1.çevrede ve 3.çevrede 3 çevrimi

Aynı noktayı alırsa yük farklı çevrelerin

1.çevre			2.çevre			3.çevre		
△	∅	□	△	∅	□	△	∅	□
11	11	11	(21)	21	21	(31)	31	(31)
(12)	12	12	(22)	22	22	(32)	(32)	(32)
(13)	13	(13)	(23)	(23)	(23)	33	(33)	33

$\blacktriangle = j25\Omega$ $\quad$ $\blacksquare = j5\Omega$ $\quad$ $\varnothing = j15\Omega$

1.çevre $10I_1 + j20(I_1 - I_2) - j25I_2 + j25I_3 - j5I_3 = 220 + j0$

1.çevrede kuralı için ∅ yok

I_1 üçgene giriyor I_2 j20'li üçgenden çıkıyor.

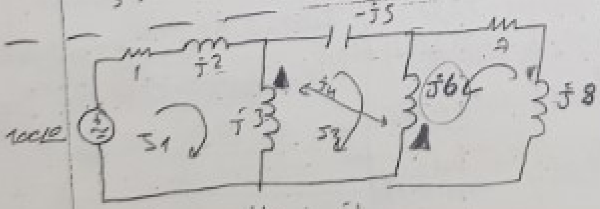
I_1 1.çevredeki 3 gene girerken 3.çevrede 3 gene giriyor

2.çevre $j40(I_2 - I_3) + 30I_2 + j20(I_2 - I_1) - j25I_1 - j25I_3 + 2\cdot j25I_2 + j15I_3 + j5I_3 = 0$

$$\begin{bmatrix} 10+j20 & -j45 & j20 \\ -j45 & 30+j110 & -j45 \\ j20 & -j45 & 9+j20 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 220/0 \\ 0 \\ 0 \end{bmatrix}$$

3.çevre $(9 + j10)I_3 + j40(I_3 - I_2) + j25 \cdot I_1 - j25 \cdot I_2 + j15 I_2 - 2j15 \cdot I_3 - j5 I_1 + j5 I_2 = 0$

aynı 33 noktası için

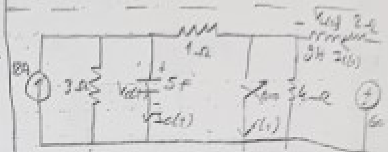


j4	j4	j4
11	(21)	(31)
(12)	(22)	(32)
(13)	23	33

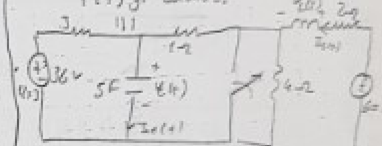
1.çevre $(1 + j2)I_1 + j3(I_1 - I_2) - j4I_3 - j4I_2 = 100/0$

2.çevre $j3(I_2 - I_1) - j5I_2 + j6(I_2 + I_3) + 2 \times j4 \cdot I_2 + j4 \cdot I_3 - j4 I_1 = 0$

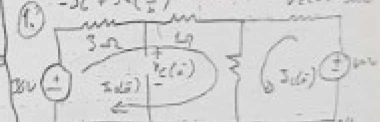
3.çevre $j6(I_3 + I_2) + (2 + j8) \cdot I_3 - j4 \cdot I_1 + j4 \cdot I_2 = 0$

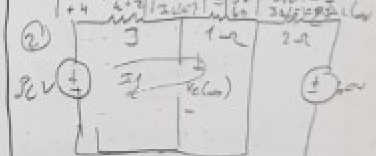


Anahtar uzun süre açık kaldıktan sonra t=0 anında kapatılıyor. t>0 için i(t)'yi bulunuz.



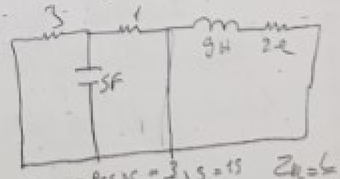
$-36 + 3i_c(-3) + V_c(0^-) = 0 \quad V_c(0^-) = 36$





$I_1 = 3A$ $\quad -36 + 3 \times 3 + V_c(\infty) = 0$

$I_L(\infty) = \frac{60}{2} = 30A \quad V_c(\infty) = 9V$



$Z_{RC} = R_{eş} \times C = \frac{3}{4} \cdot 5 = \frac{15}{4}$

$R_{eş} = \frac{3 \times 1}{3 + 1}$

$V_C(t) = A \cdot e^{-t/\tau} + V_C(\infty) = A \cdot e^{\frac{-6.4}{3}t} + 9$

$t = 0 \quad V_C(0^+) = 38.25$

$38.25 = A + 9 \Rightarrow A = 29.25$

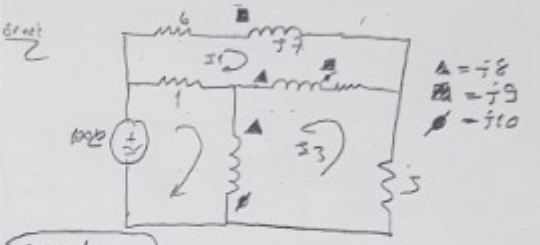
$i_C(t) = 29.25\, e^{-6.4t} + 9$

$i_L(t) = A \cdot e^{-\frac{t}{\tau}} + I_L(\infty) = A \cdot e^{\frac{-3t}{5}} + 30$

$t = 0 \Rightarrow 10.5 = A + 30 \Rightarrow A = -19.5$

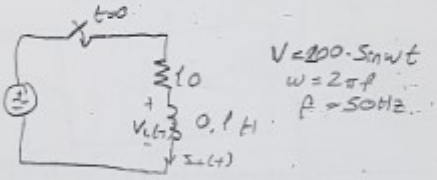
$I_L(t) = -19.5\, e^{-\frac{3}{5}t} + 30 \qquad I_L(t) = I_2(t)$

$i(t) = i_C(t) + i_L(t) = 29.25 \cdot e^{-6.4t} + 9 - 19.5 \cdot e^{-\frac{3}{5}t} + 30,$



AC transient

AC devreye giriş akımları ve gerilimleri



$V = 200 \cdot \sin \omega t$

$\omega = 2\pi f$

$f = 50\,Hz$

$Z = \frac{L}{R_{eş}} = \frac{0.1}{10} = 0.01 \qquad Y = \frac{1}{Z} = 100$

$I_L(0^-) = 0 = I_L(0^+)$

$I_L(\infty) = I_{L_{ort}} = \frac{V}{Z} = \frac{200/\sqrt{2}\,\angle 0^\circ}{10 + j314 \times 0.1} = \frac{200/\sqrt{2}\angle 0}{10 + 31.4j}$

$\rightarrow \frac{200/\sqrt{2}\angle 0}{33\angle 72.3} = \frac{6.06}{\sqrt{2}}\angle -72.3 = I_L(\infty)$

$I_L(t) = I_L(0_t) + I_L(\infty)$

$I_L(t) = A \cdot e^{-t/\tau} + \left(\frac{6.06}{\sqrt{2}} \cdot \sin(314t - 72.3)\right)$

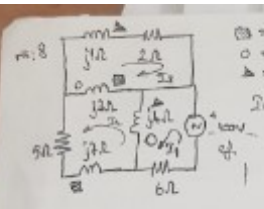
$t = 0$

$I_L(0^+) = 0 \qquad 0 = 0.1 + 6.06 \cdot \sin(-72.3^\circ)$

$A = 5.78$

$I_L(t) = 5.78 \times e^{-\frac{t}{0.01}} + 6.06 \cdot \sin(314t - 72.5^\circ)$

$V_L(t) = L \cdot \frac{di_L(t)}{dt} = 0.1\left[5.78\left(\frac{-1}{0.01}\right) \cdot e^{-100t} + 6.06 \cdot \cos(314t - 72.5)\right)$



□ = j25 Ω
○ = j15 Ω
△ = j5 Ω

$I_1, I_2, I_3 = ?$

1. çevre ⇒ $6I_1 - j4(I_1 - I_2) - j5I_2 + j15I_3 + j15I_2 = 100$

2. çevre ⇒ $(5+j7)I_2 + j4(I_2 - I_1) + j3(I_2 + I_3) + 2 \cdot j25 I_2 + j25 I_2 - 2 \cdot j15 I_2 + j15 I_1 - j15 I_3 + j5 I_3 = 0$

çevre ⇒ $(2+j4) I_3 + j3(I_2 + I_3) + j25 I_2 - j15 I_2 + j15 I_1 + j5 I_2 - j5 I_1 = 0$

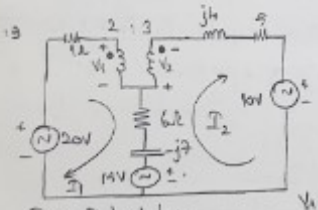
⇒ $(6 - j4) I_1 + (j4 + j15) I_2 + (j15 - j5) I_3 = 100$

⇒ $(j15 - j4) I_1 + (5 + j7 + j4 + j3 + j50 - j30) I_2 + (j3 + j25 - j15 + j5) I_3 = 0$

⇒ $(j15 - j5) I_1 + (j5 - j15 + j3 + j25) I_2 + (2 + j1 + j3) I_3 = 0$

Matris ⇒

$$\begin{vmatrix} 6-j4 & j19 & j10 \\ j11 & 5+j34 & j18 \\ j10 & j18 & 2+j4 \end{vmatrix} \begin{vmatrix} I_1 \\ I_2 \\ I_3 \end{vmatrix} = \begin{vmatrix} 100 \\ 0 \\ 0 \end{vmatrix}$$



I_1 ve I_2'yi bulun.

Çözüm. Transformatör mantığı:

$\frac{V_1}{V_2} = -\frac{2}{3}$ $\quad \frac{I_1}{I_2} = \frac{3}{2}$

1. çevre ⇒ $1I_1 + (6 - j7)(I_1 - I_2) + V_1 = 5$

2. çevre ⇒ $(j4+5) I_2 + (6 - j7)(I_2 - I_1) + V_2 = 5$

$V_1 = -\frac{2}{3} V_2$ $\quad I_1 = \frac{3}{2} I_2$ yerine yazalım.

$\frac{3}{2} I_2 + (6 - j7)\left(\frac{3}{2} I_2 - I_2\right) - \frac{2}{3} V_2 = 5 \Rightarrow \left(\frac{3}{2} - \frac{j7}{2}\right) I_2 - \frac{2}{3} V_2 = 5$

$(j4+5) I_2 + (6 - j7)\left(I_2 - \frac{3}{2} I_2\right) + V_2 = 5 \Rightarrow \left(2 + \frac{j15}{2}\right) I_2 + V_2 = 5$ ⇒ 3 ile çarpalım

$\left(\frac{3}{2} - \frac{j7}{2}\right) I_2 - \frac{2}{3} V_2 = 5$

$\left(\frac{4}{3} + j5\right) I_2 + \frac{2}{3} V_2 = \frac{10}{3}$

$$I_2 = \frac{\frac{25}{3}}{\frac{35}{6} + \frac{j3}{2}} = \frac{25}{3}\left(\frac{2}{j3+35}\right) = \frac{50}{j3+35}$$

$I_2 = 1{,}38 \angle -16{,}02$ bulunur.

- 2. Yöntemden

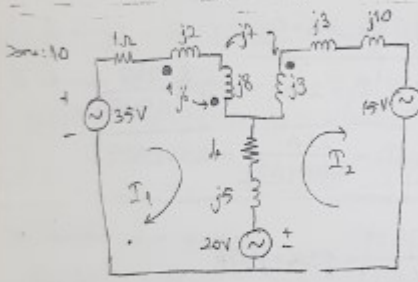
$$\left(2+\frac{j14}{2}\right)I_1 + V_2 = 5 \Rightarrow \left(\frac{4+j15}{2}\right)\left(\frac{50}{j9+35}\right) - 5 = V_2$$

$$\frac{200+j750}{70+j18} - 5 = V_2$$

$$(70-j18)$$

$$\frac{(200+j750)(70-j18)}{70^2+18^2} - 5 = \frac{27900+j48300}{5224} - 5 = 0.26 + j9.36$$

$$I_1 = \frac{3}{2}I_1 = \frac{3}{2}\left(1.38\angle -16.02\right) = 2.07\angle -16.02$$



Kuplajlı zorlu kip

Çözüm:

1. çevre ⇒

$$(1+j2+j8)I_1 + (4+j5)(I_1-I_2) - 2j6\cdot I_1 + j7 I_2 = 15$$

2. çevre ⇒

$$(j3+j3+j10)I_2 + (4+j5)(I_2-I_1) + j7\cdot I_1 = 5$$

1. çevre ⇒ $(1+j2+j8+4+j5+j12)I_1 + (j7-4-j5)I_2 = 15$

2. çevre ⇒ $(j7-4-j5)I_1 + (j9+j3+j10+4+j5)I_2 = 5$

Matris

$$\begin{vmatrix} 5+j27 & -4+j2 \\ -4+j2 & 4+j27 \end{vmatrix} \begin{vmatrix} I_1 \\ I_2 \end{vmatrix} = \begin{vmatrix} 15 \\ 5 \end{vmatrix}$$

$$I_1 = \frac{\begin{vmatrix} 15 & -4+j2 \\ 5 & 4+j27 \end{vmatrix}}{\begin{vmatrix} 5+j27 & -4+j2 \\ -4+j2 & 4+j27 \end{vmatrix}} = \frac{80+j395}{-721+j259} = \frac{403.02\angle 87.28}{766.11\angle -21.95} = 0.53\angle 109.23$$

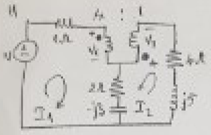
$$I_2 = \frac{\begin{vmatrix} 5+j27 & 15 \\ -4+j2 & 5 \end{vmatrix}}{766.11\angle -21.95} = \frac{85+j109}{766.11\angle -21.95} = \frac{135.03\angle 96.68}{766.11\angle -21.95}$$

$$I_2 = 0.18\angle 78.63$$

$= j5\,\Omega$ Çözüm

1\. çevre ⇒ $6I_1 - j4(I_1 - I_2) - j5I_2 + j15I_3$

= Transformatör =



$\dfrac{I_1}{I_2} = \dfrac{1}{4}$ $\dfrac{V_1}{V_2} = \dfrac{4}{1}$

V_1, V_2, I_1, I_2'yi bulun.

1\. çevre ⇒ $1 \cdot I_1 + V_1 + (2 - j3)(I_1 + I_2) = 260$

2\. çevre ⇒ $(4 + j5)I_2 - V_2 + (2 - j3)(I_2 + I_1) = 0$

1 ⇒ $(3 - j3)I_1 + (2 - j3)I_2 + V_1 = 260$

2 ⇒ $(2 - j3)I_1 + (6 + j2)I_2 - V_2 = 0$

$I_2 = 4I_1$, $V_1 = 4V_2$ yerine yazalım ⇒

$(3 - j3)I_1 + (2 - j3)(4I_1) + 4V_2 = 260$

$(2 - j3)I_1 + (6 + j2)(4I_1) - V_2 = 0$

$I_2 = 4I_1$

$I_2 = 9{,}04\angle{-2{,}77}$

Düzenleyelim ⇒ $(11 - j15)I_1 + 4V_2 = 260$

$4(26 + j5)I_1 - 4V_2 = 0$

$(115 + j5)I_1 = 260 \Rightarrow I_1 = \dfrac{260}{115 + j5}$

$I_1 = \dfrac{260}{115{,}11\angle 2{,}77} = 2{,}26\angle{-2{,}77}$

1\. denklemden

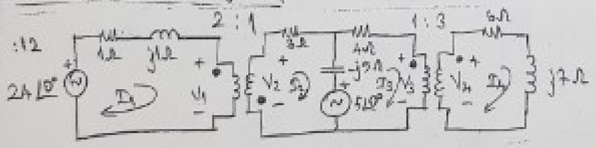
$V_2 = \dfrac{260 - (11 - j15)(2{,}26\angle{-2{,}77})}{4}$

$= \dfrac{260 - (18{,}6\angle{-53{,}72})(2{,}26\angle{-2{,}77})}{4}$

$V_2 = \dfrac{260 - (42{,}04\angle{-62{,}49})}{4} = \dfrac{236{,}64 + j34{,}95}{4} = 59{,}16 + j8{,}74$

$V_1 = 4V_2 = 236{,}64 + j34{,}96$

:12

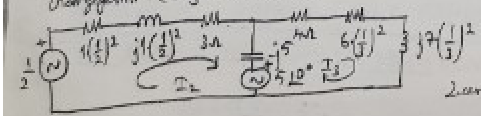


$I_1, I_2, I_3, I_4, V_1, V_2, V_3, V_4$'ü bulun.

Çözüm:

$\dfrac{I_1}{I_2} = -\dfrac{1}{2}$ $\dfrac{I_3}{I_4} = \dfrac{3}{1}$ $\dfrac{V_1}{V_2} = -\dfrac{2}{1}$ $\dfrac{V_3}{V_4} = \dfrac{1}{3}$

İndirgeyelim. (sağdan ve soldan)



Çevre yazalım

1\. çevre ⇒ $\left(\dfrac{1}{4} + \dfrac{j}{4} + 3\right)I_2 - j5(I_2 - I_3) = 12 - 5$

2\. çevre ⇒ $\left(4 + \dfrac{2}{3} + j\dfrac{7}{9}\right)I_3 - j5(I_3 - I_2) = 5$

Matris

$$\begin{vmatrix} \left(\frac{13}{4}+\frac{3}{4}-j5\right) & j5 \\ j5 & \frac{14}{3}+j\frac{7}{3}-j3 \end{vmatrix} \begin{vmatrix} I_2 \\ I_3 \end{vmatrix} = \begin{vmatrix} 7 \\ 5 \end{vmatrix} \Rightarrow I_2 = \frac{\begin{vmatrix} 2 & j5 \\ 5 & \frac{14}{3}-j\frac{28}{9} \end{vmatrix}}{\begin{vmatrix} \frac{13}{4}-\frac{j13}{4} & j5 \\ j5 & \frac{14}{3}-j\frac{28}{9} \end{vmatrix}}$$

$$I_2 = \frac{32,62 - j24,96}{-4,89 - j35,83} = \frac{63,99\angle -65,65}{36,22\angle 91,38} = 1,76\angle -157,03$$

$$I_3 = \frac{\begin{vmatrix} \frac{13}{4}-\frac{j13}{4} & 7 \\ j5 & 5 \end{vmatrix}}{36,22\angle 91,38} = \frac{16,25 - j58,79}{36,22\angle 91,38} = \frac{60,96\angle -82,82}{36,22\angle 91,38} = 1,68\angle -174,2$$

$$I_1 = -\frac{1}{2}I_2 = -0,88\angle -157,03 \qquad I_4 = \frac{I_3}{3} = 0,56\angle -174,2$$

İlk devreden ana yazalım.

$$(1+j1)\,I_1 + V_1 = 24 \Rightarrow V_1 = 24 + \left(1,41\angle 45^\circ\right)\left(0,88\angle -157,03\right) = 24 + 1,24\angle -107,03$$

$$V_1 = 23,86 - j1,23 \qquad V_2 = -\frac{V_1}{2} = -11,93 + j0,619$$

Son devreden ana yazalım.

$$(6+j7)\,I_4 - V_4 = 0 \Rightarrow V_4 = \left(9,22\angle 54,83\right)\left(0,56\angle -174,2\right) = 5,16\angle -119,31$$

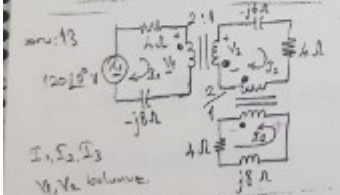
$$V_2 = \frac{V_4}{3} = 1,72\angle -119,31$$

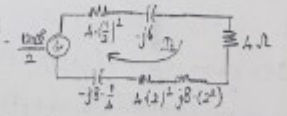
Çözüm

$$\frac{V_1}{V_2} = -\frac{2}{1}$$

$$\frac{I_1}{I_2} = -\frac{1}{2}$$

$$\frac{I_2}{I_3} = -\frac{1}{2}$$





İndirgeyelim (2 taraflım)

$$I_2\left(1 - j6 + 4 - j2 + 16 + j32\right) = 60$$

$$I_2\left(21 + j24\right) = 60$$

$$I_2 = \frac{20}{7+j8} = \frac{20}{10,63\angle 34,24}$$

$$I_2 = 18,81\angle -54,24$$

I_1, I_2, I_3 V1, V2 bulunur.

$$I_1 = -\frac{I_2}{2} = -9,41\angle -54,24$$

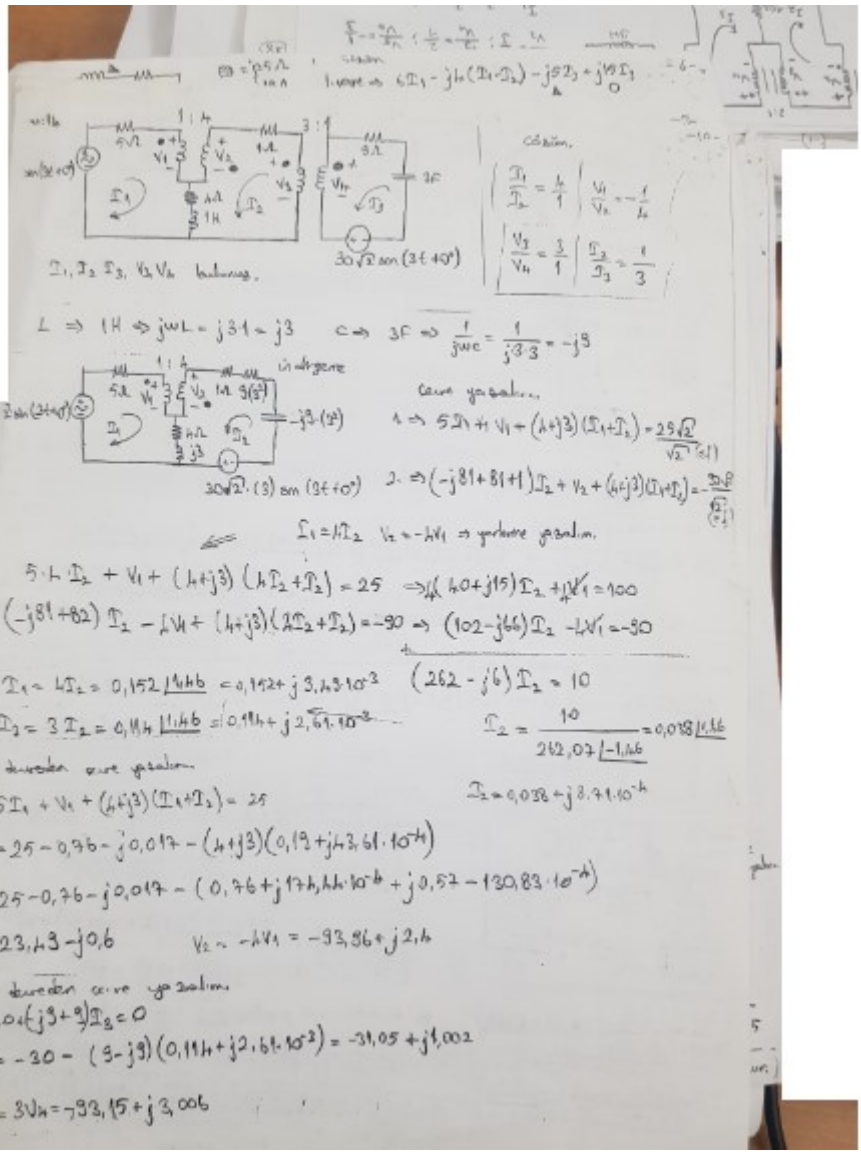
$$I_3 = -2\cdot I_2 = -37,62\angle -54,24$$

İlk devreden ana yazalım.

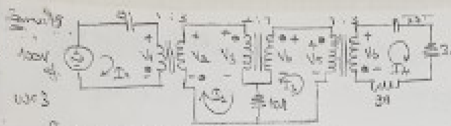
$$V_1 = 120\angle 0^\circ - (4-j8)\,I_1$$

$$V_1 = 120\angle 0^\circ + 83,13\angle 124,72$$

$$V_2 = -\frac{V_1}{2} = -60\angle 0^\circ - 42,07\angle 124,72$$



Soru 19



$\frac{V_1}{V_2} = \frac{1}{3}$ $\frac{V_3}{V_4} = \frac{2}{1}$ $\frac{V_5}{V_6} = -\frac{1}{2}$

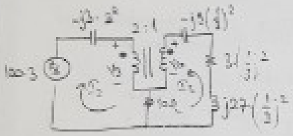
$\frac{I_1}{I_2} = \frac{3}{1}$ $\frac{I_2}{I_3} = -\frac{1}{2}$ $\frac{I_3}{I_4} = \frac{3}{1}$

$w = 3$

$I_1, I_2, I_3, I_4, V_1, V_2, V_3, V_4, V_5, V_6$ bulunuz.

Çözüm: (indirgeme (sağ ve sol))

$C \Rightarrow \frac{1}{j\omega C} = \frac{1}{j \cdot 3 \cdot \frac{1}{9}} = -j3$ $\frac{1}{j\omega C} = \frac{1}{j3\frac{1}{27}} = -j9$



$L \Rightarrow j\omega L = j3 \cdot 9 = j27$

$-j27 I_2 + V_3 + 10(I_2 + I_3) = 300 \Rightarrow (10 - j27) I_2 + 10 I_3 + V_3 = 300$ $V_3 = 2V_4$

$\left(j3 + \frac{1}{3} - j1\right) I_3 + V_4 - 10(I_2 + I_3) = 0 \Rightarrow \left(j2 + \frac{31}{3}\right) I_3 + 10 I_2 + V_4 = 0$ $I_3 = -2I_2$

$(10 - j27) I_2 + 10(-2I_2) + 2V_4 = 300 \Rightarrow (-10 - j27) I_2 + 2V_4 = 300$

$\left(j2 + \frac{31}{3}\right)(-2I_2) + 10 I_2 + V_4 = 0 \Rightarrow 2\left(j4 + \frac{32}{3}\right) I_2 - 2V_4 = 0$

$\left(-j13 + \frac{34}{3}\right) I_2 = 300$

$I_2 = \frac{900}{66,37 \angle -65,76} = 13,56 \angle 65,76$

$I_2 = \frac{300 \cdot 3}{(-j57 + 34)} = \frac{300}{(34 - j57)}$

$I_1 = 3I_2 = 40,68 \angle 65,76$

$I_3 = -2I_2 = -27,12 \angle 65,76$

$(-10 - j27) I_2 + 2V_4 = 300$

$(28,79 \angle 77,42)(13,56 \angle 65,76) + 2V_4 = 300$

$I_4 = \frac{I_3}{3} = -9,04 \angle 65,76$

$390,39 \angle 143,18 + 2V_4 = 300 \Rightarrow V_4 = \frac{300 - 390,39 \angle 143,18}{2} = \frac{544,95 - j303,98}{2}$

$V_4 = 272,48 - j151,99$

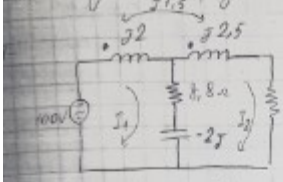
$V_3 = 2V_4 = 544,96 - j303,98$

V_1 devreden bulalım

$V_1 - j3I_1 - 100 = 0 \Rightarrow V_1 = 3\angle 90° (40,68 \angle 65,76) + 100 = 122,04 \angle 155,76 + 100$

$V_1 = 6,26 + j78,15$ $V_2 = 3V_1 = 18,78 + j234,45$

Manyetik Kuplaj



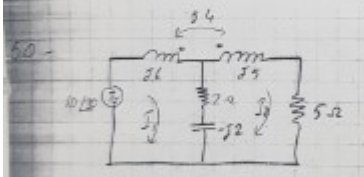
$2jI_1 + (8,8-2j)(I_1-I_2) + j1,5I_2 = 100$

$(2,5j+2)I_2 + (8,8-2j)(I_2-I_1) + j1,5I_1 = 0$

$I_2 = 13,34 \angle -86,81$

$V_{out} = 2 \cdot 13,34 \angle -86,81 = 26,68 \angle -86,81$

50 -



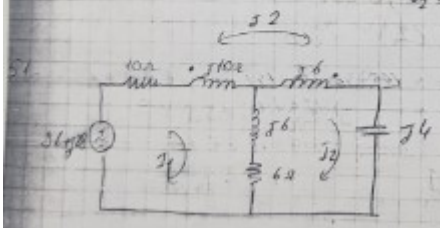
$j6I_1 + (2-j2)(I_1-I_2) - j6I_2 = 10 \angle 0°$

$(j5+5)I_2 + (2-j2)(I_2-I_1) - j4I_1 = 0$

$I_2 = 2,3 \angle 9$

$V_2 = 5 \cdot 2,3 \angle 2° = 11,5 \angle 9$

51



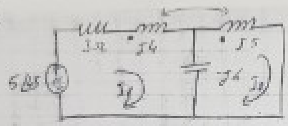
$(16+j10)I_1 + (j6+6)(I_1-I_2) - j2I_2 = 36 \angle 0°$

$(j6-j4)I_2 + (j6+6)(I_2-I_1) - j2I_1 = 0$

$I_2 = 9,62 \angle 137,5$ $V_{out} = 4 \angle 90° \cdot 9,62 \angle 137,5 = 38,48 \angle 227,5$

52-

4'



$(3+j4)I_1 - j6(I_1 - I_2) + j3 I_2 = 5\angle 45^\circ$

$-j5 I_2 - j6(I_2 - I_1) + j3 I_1 = 0$

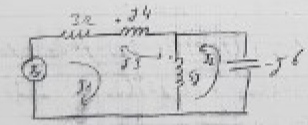
$(3-j2)I_1 + j9 I_2 = 5\angle 45^\circ$

$9/\ j9 I_1 - j I_2 = 0$

$(3+j79)I_1 = 5\angle 45^\circ \Rightarrow I_1 = \dfrac{5\angle 45}{79\angle 87{,}82} = 0{,}063\ \angle -42{,}82$

$I_2 = 9I_1 \Rightarrow I_2 = 0{,}567\ \angle -42{,}82$

4 53-



$(3+j4)I_1 + j5(I_1+I_2) + j3 I_1 + j3(I_2+I_1) = 5\angle 45^\circ$

$-j6 I_2 + j5(I_2+I_1) + j3(I_1) = 0$

$(3+j4+j5+j3+j3)I_1 + (j5+j3)I_2 = 5\angle 45 \Rightarrow (3+j15) I_1 + j8 I_2 = 5\angle 45$

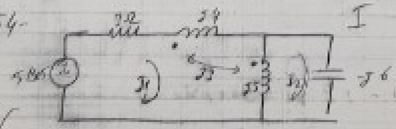
$(j5+j3)I_1 + (-j6+j5) I_2 = 0 \Rightarrow 8/\ j8 I_1 - j I_2 = 0$

$3+j79\ I_1 = 5\angle 45$

$I_1 = \dfrac{5\angle 45}{79\angle 87{,}82} = 0{,}063\ \angle -42{,}82$

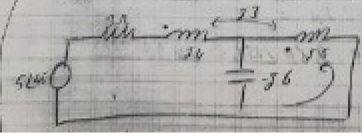
$I_2 = 8I_1 = 0{,}504\ \angle -42{,}82$

54-



I

bu şekle dönüştürebiliriz



II

$(3+j5)\,I_1 - 8j\,I_2 = 5\angle 45°$

$-8j\,I_1 - j\,I_2 = 0$

$(3+j4)\,I_1 - j6\,(I_1+I_2) - j3\,I_2 = 5\angle 45$

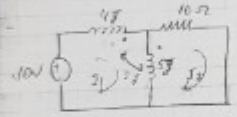
$j5\,I_2 - j6\,(I_2+I_1) - j3\,I_1 = 0$

$(3+j4-j6)I_1 + (-j6-j3)I_2 = 5\angle 45$

$-(j6-j3)I_1 + (j5-j6)I_2 = 0$

$(3-2j)\,I_1 - j8\,I_2 = 5\angle 45$

$-j9\,I_1 - j\,I_2 = 0$



$4j\,I_1 + 5j\,(I_1-I_2) - j\,2\,I_1 + j2\,(I_2-I_1) = 10$

$10\,I_2 + j5\,(I_2-I_1) + 6j\,I_1 = 0$

$(4j+5j-2j-2j)\,I_1 + (5j+2j)\,I_2 = 10$

$(-5j+8j)\,I_1 + (10+j5)\,I_2 = 0 \Rightarrow I_1 = \frac{-10-5j}{3j}\,I_2$

$= \frac{11,18\angle -153}{-3\angle 90}$

$I_1 = -3,73\angle 63,5\,I_2$

$5\angle 90 \cdot -3,73\angle -63,5\,I_2 + 3\angle 90\,I_2 = 10$

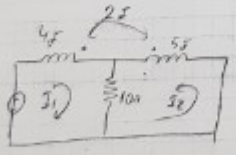
$-18,65\angle -153 \cdot 3\angle 90\,I_2 = 10$

$(16,62 + 5,46j)\,I_2 = 10$

$I_2 = \frac{10}{13,5\angle 18,18} = 0,541\angle -18,18$

$I_1 = 2,12\angle -261,18$

?



$4j\,I_1 + 10\,(I_1+I_2) + j2\,I_1 = 10$

$5j\,I_2 + 10\,(I_2+I_1) + j2\,I_1 = 0$

$(4j+10)\,I_1 + (10+j2)\,I_2 = 10$

$(10+j2)\,I_1 + (5j+10)\,I_2 = 0 \Rightarrow I_1 = -\frac{10+5j}{10+2j}\,I_2$

$10,44\angle 268,1\,\angle -166,3\,I_2 + 10,2\angle 168,3\,I_2 = 10$

$I_1 = 1,09\angle 166,3\,I_2$

$(11,44\angle -142,5 + 10,2\angle 168,3)\,I_2 = 10$

$(0,688 - 5,18j)\,I_2 = 10$

$5,18\angle -82,3\,I_2 = 10$

$I_2 = 1,93\angle 82,3\,A \quad I_1 = 2,1\angle -82\,A$