① VASTUKSET OVAT SARJASSA. KOKONAISRESISTANSSI ON $R_1 + R_2 = 560\,\Omega + 220\,\Omega = 780\,\Omega$

$$I = \frac{U}{R} = \frac{10\,V}{780\,\Omega} = 0{,}0128\,A = 12{,}8 \cdot 10^{-3}\,A \approx 13\,mA$$

VIRTA AIHEUTTAA 220 Ω:N VASTUKSESSA JÄNNITEHÄVIÖN $U_{220} = R_{220} \times I = 220\,\Omega \cdot 12{,}8 \cdot 10^{-3}\,A = 2{,}8\,V$

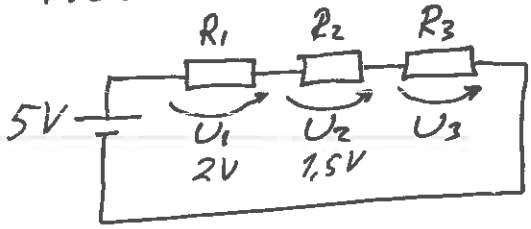
220 Ω:N VASTUKSEN KULUTTAMA TEHO

$$P = U \cdot I = 2{,}8\,V \cdot 12{,}8 \cdot 10^{-3}\,A \approx 36\,mW$$

② KIRCHHOFFIN JÄNNITELAIN MUKAAN

$$U_1 + U_2 + U_3 = 5\,V$$

$$U_3 = 5\,V - U_1 - U_2 = 5\,V - 2\,V - 1{,}5\,V = 1{,}5\,V$$



③ 10 kΩ:N VASTUKSESSA VIRTA I AIHEUTTAA 3,3 V:N JÄNNITEHÄVIÖN. OHMIN LAIN MUKAAN

$$I = \frac{U}{R} = \frac{3{,}3\,V}{10 \cdot 10^3\,\Omega} = 3{,}3 \cdot 10^{-4}\,A = 330 \cdot 10^{-6}\,A = 330\,\mu A$$

U_x ON KIRCHHOFFIN JÄNNITELAIN MUKAAN

$$4{,}5\,V - 3{,}3\,V = 1{,}2\,V$$

$$R_x = \frac{U_x}{I} = \frac{1{,}2\,V}{330 \cdot 10^{-6}\,A} = \frac{1{,}2\,V \cdot 10^6\,V}{330\,A} = 3{,}6 \cdot 10^3\,\Omega = 3{,}6\,k\Omega$$

④ KIRCHHOFFIN VIRTALAIN MUKAAN

$5mA = 1mA + I_3$ JOTEN $I_3 = 4mA$

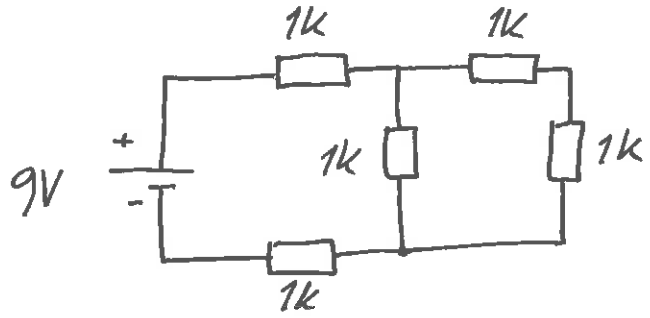
⑤ VIHREÄ SININEN KELTAINEN HOPEA

5 6 10^4 $\pm 10\%$

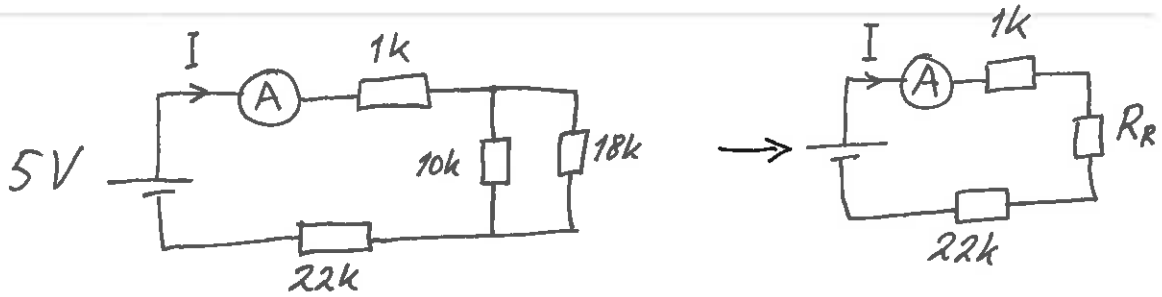
$560000 = 560k\Omega \pm 56k\Omega$

$504k\Omega \dots 616k\Omega$

⑥



⑦



R_R ON 10kΩ:N JA 18kΩ:N RINNANKYTKENNÄN RESISTANSSI $R_R = \frac{10 \cdot 10^3 \cdot 18 \cdot 10^3}{10 \cdot 10^3 + 18 \cdot 10^3} = 6{,}4k\Omega$

PIIRIN KOKONAISRESISTANSSI ON $1k\Omega + 6{,}4k\Omega + 22k\Omega = 29{,}4k\Omega$

$I = \frac{U}{R_{kok}} = \frac{5V}{29{,}4 \cdot 10^3 \Omega} = 0{,}170 \cdot 10^{-3} A = 170\mu A$

(8) JÄNNITELÄHTEET OVAT VASTAKKAIN JOTEN PIIRISSÄ VAIKUTTAA $10V - 6V = 4V$:N LÄHDE-JÄNNITE, U_s

PIIRIN KOKONAISRESISTANSSI $= 1k\Omega + 1{,}8k\Omega = 2{,}8k\Omega$

VIRTA $I = \frac{U_s}{R_{koh}} = \frac{4V}{2{,}8 \cdot 10^3 \Omega} = 1{,}4 \cdot 10^{-3} A = 1{,}4mA$

1,8k:N VASTUKSEN JÄNNITEHÄVIÖ $U = R \cdot I = 1{,}8 \cdot 10^3 \Omega \cdot 1{,}4 \cdot 10^{-3} A$

$= 2{,}57V \approx 2{,}6V$

(9) $R_{koh} = 0{,}27M\Omega + 56000\Omega + 100k\Omega$

$= 270k\Omega + 56k\Omega + 100k\Omega = 426k\Omega$

(10) VASTUKSET OVAT RINNAKKAIN

$$\frac{1}{R_{koh}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5}$$

$$= \frac{1}{10k} + \frac{1}{10k} + \frac{1}{10k} + \frac{1}{10k} + \frac{1}{10k} = \frac{5}{10k}$$

$$\rightarrow R_{koh} = \frac{10k\Omega}{5} = 2k\Omega$$

(11) VASTUKSET OVAT SARJASSA, KOKONAISRESISTANSSI ON $4k + 6k = 10k\Omega$

$$I = \frac{U}{R_{koh}} = \frac{10V}{10 \cdot 10^3 \Omega} = 10^{-3} A = 1mA$$

6kΩ:N VASTUKSEN JÄNNITEHÄVIÖ $U = RI = 6k\Omega \cdot 1mA$

$= 6 \cdot 10^3 \Omega \cdot 1 \cdot 10^{-3} A = 6V$

VOIDAAN LASKEA MYÖS JÄNNITTEENJAKOKAAVALLA

$$U = \frac{6k}{4k + 6k} \cdot 10V = 6V$$

(12) KOKONAISRESISTANSSI ON $1k+2k+5k = 8k\Omega$

$$I = \frac{U}{R_{koh}} = \frac{5{,}0V}{8\cdot10^3\Omega} = 0{,}63\cdot10^{-3}A = 630\cdot10^{-6}A = 630\mu A$$

$U_1 = R_1 \cdot I = 1k\Omega \cdot 630\mu A = 10^3\Omega \cdot 630\cdot10^{-6}A = 0{,}63V$

$U_2 = R_2 \cdot I = 2\cdot10^3\Omega \cdot 630\cdot10^{-6}A = 1{,}26V$

$U_3 = R_3 \cdot I = 5\cdot10^3\Omega \cdot 630\cdot10^{-6}A = 3{,}15V$

TARKISTUS: KIRCHHOFFIN JÄNNITELAIN MUKAAN

$U_1 + U_2 + U_3 = 5{,}0V \approx 0{,}63V + 1{,}26V + 3{,}15V$

(13) KAIKKIEN VASTUSTEN JÄNNITEHÄVIÖ ON 10V

$$I_1 = \frac{U}{R_1} = \frac{10V}{1\cdot10^3\Omega} = 10\cdot10^{-3}A = 10mA$$

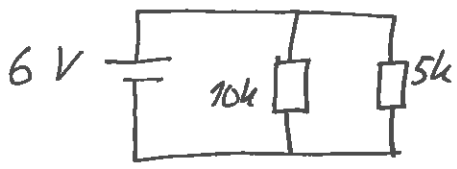
$$I_2 = \frac{U}{R_2} = \frac{10V}{2\cdot10^3\Omega} = 5\cdot10^{-3}A = 5mA$$

$$I_3 = \frac{U}{R_3} = \frac{10V}{6\cdot10^3\Omega} = 1{,}67\cdot10^{-3}A = 1{,}67mA$$

KOKONAISVIRTA $I = I_1 + I_2 + I_3 = 10mA + 5mA + 1{,}67mA \approx 16{,}7mA$

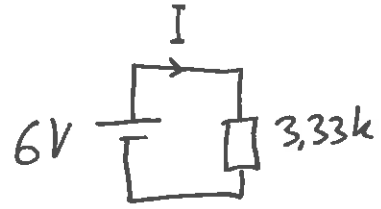
(14) 1kΩ:N JA 4kΩ:N SARJAKYTKENNÄN

KOKONAISRESISTANSSI = $1k + 4k = 5k\Omega$



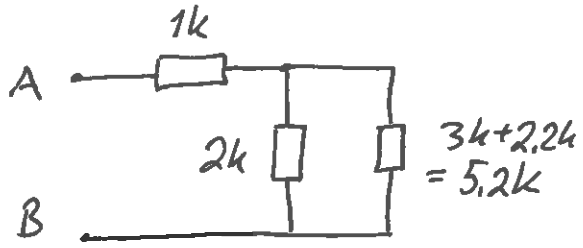
10k:N JA 5k:N RINNAKKAISKYTKENNÄN KOKONAISRESISTANSSI ON

$$\frac{10\cdot10^3\Omega \cdot 5\cdot10^3\Omega}{10\cdot10^3\Omega + 5\cdot10^3\Omega} = 3{,}33\cdot10^3\Omega$$



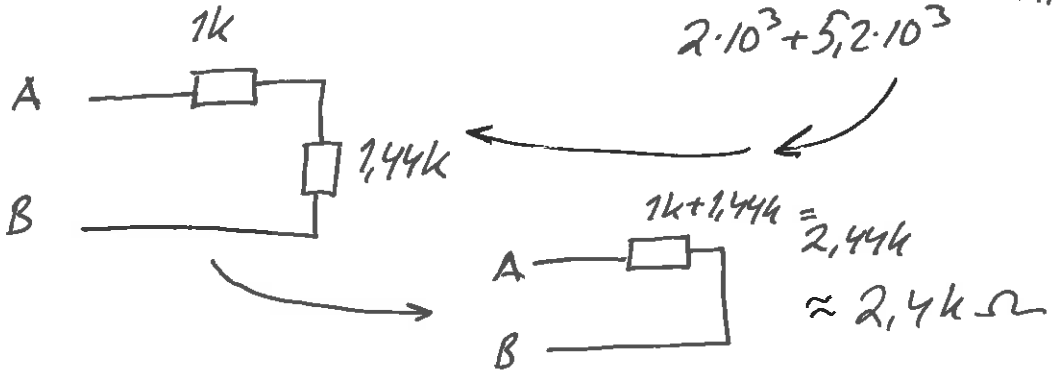
$$I = \frac{U}{R} = \frac{6V}{3{,}33\cdot10^3\Omega} = 1{,}82\cdot10^{-3}A \approx 1{,}8mA$$

(15)

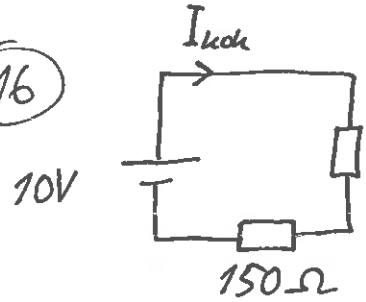


2k:n JA 5,2k:n RINNAN KYTKENNÄN KOK. RESISTANSSI

$$\frac{2\cdot10^3 \cdot 5{,}2\cdot10^3}{2\cdot10^3+5{,}2\cdot10^3} = 1{,}44\cdot10^3\,\Omega$$

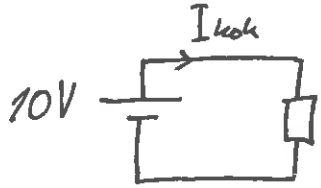


(16)



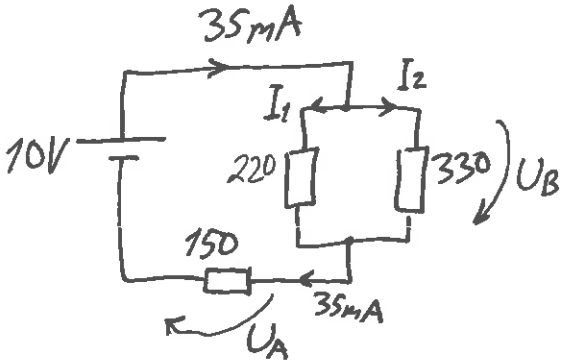
220Ω JA 330Ω RINNAKKAIN

$$\frac{220\cdot330}{220+330} = 132\,\Omega$$



150Ω + 132Ω = 282Ω

$$I_{kok} = \frac{U}{R_{kok}} = \frac{10V}{282\,\Omega} = 0{,}035A = 35mA$$



$$U_A = I_{kok}\cdot 150\,\Omega = 35\cdot10^{-3}A\cdot150\,\Omega = 5250\cdot10^{-3}V = 5{,}25V$$

$$U_B = 10V - 5{,}25V = 4{,}75V$$

$$I_1 = \frac{U_B}{220\,\Omega} = \frac{4{,}75V}{220\,\Omega} = \underline{\underline{21{,}6mA}}$$

$$I_2 = \frac{U_B}{330\,\Omega} = \frac{4{,}75V}{330\,\Omega} = \underline{\underline{14{,}4mA}}$$

TARKISTUS: 21,6mA + 14,4mA = 36mA
(PYÖRISTYSTEN VUOKSI EI TULLUT 35mA)

(17) TÄMÄ ON SÄHKÖVERKON JÄNNITE JA SEN TEHOLLISARVO = 230V

HUIPPUARVO ELI AMPLITUDI = $\sqrt{2} \cdot 230V = 325V$

HUIPUSTA HUIPPUUN-ARVO = $2 \cdot 325V = 650V$

JAKSONPITUUS ON 20 ms = T

TAAJUUS $f = \frac{1}{T} = \frac{1}{20 \cdot 10^{-3} s} = 50 \frac{1}{s} = 50Hz$

(18) $f = 15kHz$ $\quad f = \frac{1}{T} \Leftrightarrow T = \frac{1}{f} = \frac{1}{15 \cdot 10^3 Hz} = 0{,}0667 \cdot 10^{-3} s$

$\approx 67 \mu s$

$U_{TEH} = 5{,}0V$

$U_{HUIPPU} = \sqrt{2} \cdot U_{TEH} = 7{,}1V$

(19) JAKSONPITUUS 100ns = T

TAAJUUS = $f = \frac{1}{T} = \frac{1}{100 \cdot 10^{-9} s} = 10^7 Hz = 10 \cdot 10^6 Hz$

$= 10MHz$

(20) JAKSONPITUUS = T = 0,2 ms

$f = \frac{1}{T} = \frac{1}{0{,}2 \cdot 10^{-3} s} = 5 \cdot 10^3 \frac{1}{s} = 5kHz$

AMPLITUDI = 1V, DC-OFFSET = 10V

(21) VAIHE-ERO ON NELJÄSOSA JAKSONPITUUDESTA

ELI $\frac{360°}{4} = 90°$ TAI RADIAANEINA $\frac{2\pi}{4} = \frac{\pi}{2}$

(22) $f = 50Hz$ $\quad U_{TEH} = 15V$ OLETETAAN, ETTÄ SINIMUOTOISTA

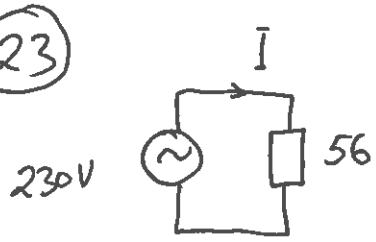
$T = \frac{1}{f} = \frac{1}{50} = 0{,}02 s = 20 ms$

HUIPPUARVO = $\sqrt{2} U_{TEH} = \sqrt{2} \cdot 15V = 21{,}2V$

HUIPPUARVO = AMPLITUDI

HUIPUSTA HUIPPUUN-ARVO = $2 \times 21{,}2V = 42{,}4V$

(23)



$$I_{TEH} = \frac{U_{TEH}}{R} = \frac{230V}{56\Omega} = 4{,}1A$$

$$I_{HUIPPU} = \sqrt{2} \cdot I_{TEH} = 5{,}8A$$

$$P = UI = 230V \cdot 4{,}1A = 943W$$

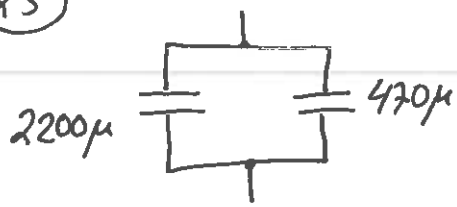
(24)

HUIPUSTA HUIPPUUN -ARVO $U_{pp} = 10V$, SIIS0IN HUIPPUARVO ELI AMPLITUDI = 5V

$$\text{TEHOLLISARVO} = \frac{5V}{\sqrt{2}} = 3{,}5V$$

NÄMÄ EIVÄT RIIPU TAAJUUDESTA.

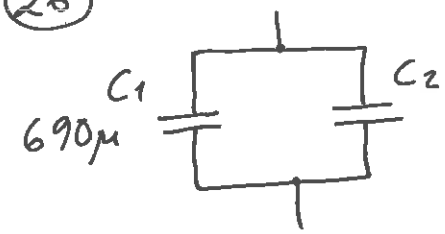
(25)



$$C_{kok} = C_1 + C_2$$

$$= 2200\mu F + 470\mu F = 2670\mu F$$

(26)

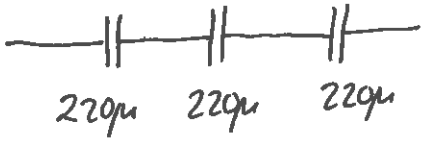


$$C_{kok} = 770\mu F$$

$$C_{kok} = C_1 + C_2, \quad C_2 = C_{kok} - C_1$$

$$C_2 = 770\mu F - 690\mu F = 80\mu F$$

(27)

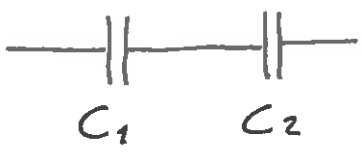


$$\frac{1}{C_{kok}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$\frac{1}{C_{kok}} = \frac{1}{220\mu F} + \frac{1}{220\mu F} + \frac{1}{220\mu F} = \frac{3}{220\mu F}$$

$$\Rightarrow C_{kok} = \frac{220\mu F}{3} = 73\mu F$$

(28)



$C_{koko} = 20\mu F$

$C_1 = 22\mu F$

$C_2 = ?$

$$\frac{1}{C_{koko}} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$\frac{1}{C_2} = \frac{1}{C_{koko}} - \frac{1}{C_1} = \frac{C_1}{C_1 \cdot C_{koko}} - \frac{C_{koko}}{C_1 C_{koko}} = \frac{C_1 - C_{koko}}{C_1 \cdot C_{koko}}$$

$$\Rightarrow C_2 = \frac{C_1 C_{koko}}{C_1 - C_{koko}} = \frac{22\mu F \cdot 20\mu F}{22\mu F - 20\mu F} = \underline{\underline{220\mu F}}$$

NÄINKIN VOI LASKEA:

$$\frac{1}{C_2} = \frac{1}{C_{koko}} - \frac{1}{C_1} = \frac{1}{20} - \frac{1}{22} = 0{,}050 - 0{,}0455$$

$$= 0{,}00455$$

$$\rightarrow C_2 = \frac{1}{0{,}00455} = 220$$

(29) $f = 3kHz \quad C = 47nF \quad X_c = ?$

$$X_c = \frac{1}{2\pi f C} = \frac{1}{2\pi 3 \cdot 10^3 \cdot 47 \cdot 10^{-9}} = \frac{10^6}{885{,}9}$$

$$= 1129\ \Omega = 1{,}1\ k\Omega$$

(30) $X_c = 3{,}3k\Omega$

$f = 5kHz$

$C = ?$

$$X_c = \frac{1}{2\pi f C} \quad | \cdot C$$

$$C \cdot X_c = \frac{1}{2\pi f} \quad | : X_c$$

$$C = \frac{1}{2\pi f X_c} = \frac{1}{2\pi 5 \cdot 10^3 \cdot 3{,}3 \cdot 10^3}$$

$$= \frac{10^{-6}}{2\pi \cdot 5 \cdot 3{,}3} = 0{,}00965 \cdot 10^{-6} F = 9{,}7 \cdot 10^{-9} F$$

$$= 9{,}7nF$$

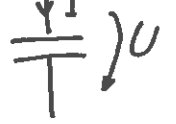
(31) $C = 10\mu F$
$X_C = 800\Omega$
$f = ?$

$$X_C = \frac{1}{2\pi f C}$$

$$f = \frac{1}{2\pi C X_C}$$

$$= \frac{1}{2\pi \cdot 10 \cdot 10^{-6} \cdot 800} = \frac{10^6}{2\pi \cdot 10 \cdot 800} = 19{,}9\,Hz \approx 20\,Hz$$

(32) $f = 50Hz$
$U_{huippu} = 9{,}7V$
$C = 470\mu F$



OHMIN LAKI TASAVIRRALLA
$I = \frac{U}{R}$

VAIHTOVIRRALLA $I = \frac{U}{X_C}$

$$X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi \cdot 50 \cdot 470 \cdot 10^{-6}} = 6{,}77\Omega$$

$$I = \frac{U}{X_C} = \frac{9{,}7V}{6{,}77\Omega} = 1{,}4A$$ HUIPPUARVO KOSKA JÄNNITEKIN OLI HUIPPUARVO

(33) $X_L = ?$
$L = 10\mu H$
$f = 50kHz$

$$X_L = 2\pi f L = 2\pi\, 50 \cdot 10^3 \cdot 10 \cdot 10^{-6}$$
$$= 3{,}14\,H$$

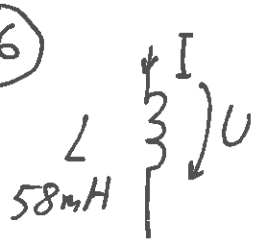
(34) $X_L = 55\Omega$
$L = 24mH$
$f = ?$

$$X_L = 2\pi f L$$
$$f = \frac{X_L}{2\pi L} = \frac{55\Omega}{2\pi \cdot 24 \cdot 10^{-3} H} = 365Hz$$

(35) $f = 10{,}0kHz$
$X_L = 822\Omega$
$L = ?$

$$X_L = 2\pi f L$$
$$L = \frac{X_L}{2\pi f} = \frac{822\Omega}{2\pi \cdot 10 \cdot 10^3 Hz} = 0{,}0131\,H$$
$$= 13{,}1\,mH$$

(36)



$f = 2\,kHz$

$U_{huippu} = 5{,}2\,V$

$I_{huippu} = ?$

$$I_{huippu} = \frac{U_{huippu}}{X_L}$$

$$X_L = 2\pi f L = 2\pi \cdot 2\cdot 10^3 \cdot 58\cdot 10^{-3} = 729\,\Omega$$

$$I_{huippu} = \frac{U_{huippu}}{X_L} = \frac{5{,}2\,V}{729\,\Omega} = 7{,}1\,mA$$

(37)

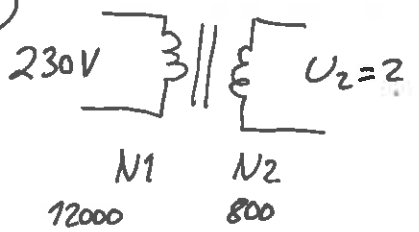
OHMIN LAKI TASAVIRRALLA: $U = RI$

VAIHTOVIRRALLA $U = X_L \cdot I$

$$X_L = 2\pi \cdot f \cdot L = 2\pi \cdot 100\cdot 10^3\,Hz \cdot 80\cdot 10^{-6}\,H = 50{,}3\,\Omega$$

$$U = X_L \cdot I = 50{,}3\,\Omega \cdot 4\cdot 10^{-3}\,A = 0{,}2\,V$$

(38)



$$\frac{U_1}{U_2} = \frac{N_1}{N_2}$$

$$U_2 = \frac{N_2}{N_1} \cdot U_1 = \frac{800}{12000} \cdot 230V = 15{,}3\,V$$

(39)

$U_1 = 220V$

$U_2 = 24V$

$N_2 = 300$

$N_1 = ?$

$$\frac{U_1}{U_2} = \frac{N_1}{N_2} \quad | \cdot N_2$$

$$\frac{N_2 \cdot U_1}{U_2} = N_1 \rightarrow N_1 = \frac{300 \cdot 220V}{24V} = 2750$$

(40)

$$\frac{N_1}{N_2} = \frac{I_2}{I_1} \rightarrow I_2 = \frac{N_1 \cdot I_1}{N_2} = \frac{400 \cdot 1{,}4A}{12}$$

$N_1 = 400$

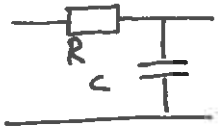
$N_2 = 12$

$I_1 = 1{,}4A$

$I_2 = ?$

$= 46{,}7A \approx 47A$

(41)



AIKAVAKIO = $\tau = RC$

$= 12 \cdot 10^3 \Omega \cdot 3 \cdot 10^{-9} F = 36 \mu s$

(42)

$C = 22 nF$

$\tau = 1{,}8 ms$

$R = ?$

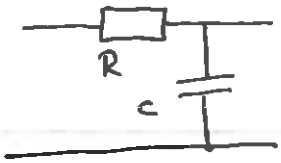
$\tau = R \cdot C$

$R = \frac{\tau}{C} = \frac{1{,}8 \cdot 10^{-3} s}{22 \cdot 10^{-9} F}$

$= 0{,}082 \cdot 10^6 \Omega = 82 \cdot 10^3 \Omega$

$= 82 k\Omega$

(43)



$f_c = \frac{1}{2\pi RC} \left(= \frac{1}{2\pi\tau} \right)$

$R = 3{,}9 k\Omega$

$C = 2{,}2 nF$

$f_c = \frac{1}{2 \cdot \pi \cdot 3{,}9 \cdot 10^3 \cdot 2{,}2 \cdot 10^{-9}} = \frac{10^6}{2 \cdot \pi \cdot 3{,}9 \cdot 2{,}2} = 18{,}5 \cdot 10^3 Hz$

$= 18{,}5 kHz$

$\approx 19 kHz$