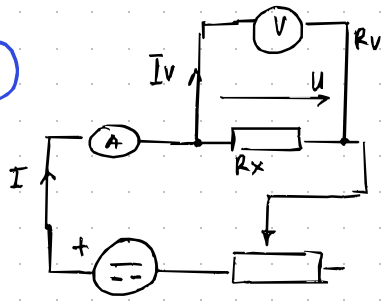
# PRIPREMA ZA ISPIT

## 1




Dig. voltmetar => M.O = 100mV

$R_V = 10M\Omega$

Analogni ampermetar => M.O = 1A

Mjerenje => $I_A = 0,925A$

$U_{V+} = 22,61mV$ $U_{V-} = -23,57mV$

$R_x = ?$

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$U_{V+} = I_A \cdot R_x + \Delta U$

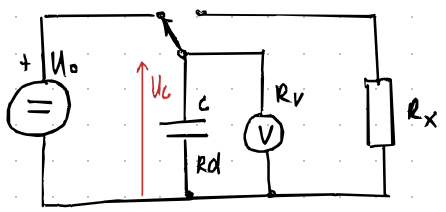
$U_{V-} = -I_A \cdot R_x + \Delta U$

$$U_V = \frac{U_{V+} - U_{V-}}{2} = \frac{I_A R_x + \Delta U + I_A R_x - \Delta U}{2} = I_A \cdot R_x$$

$$\Rightarrow R_x = \frac{1}{2I_A} \cdot (U_{V+} - U_{V-})$$

$$R_x = \frac{22,61 - (-23,57)}{2 \cdot 0,925A} = R_x = 24,96m\Omega$$

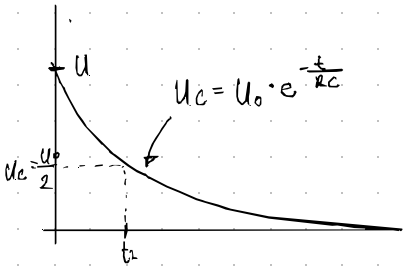
## 2




$C = 100nF$ $tg\delta = 9,2 \times 10^{-6}$ $(f = 40Hz)$

$U_0 = 50V$ $U_C = \frac{U_0}{2}$ $\Delta t = 22s$

$R_V = 10G\Omega$ $R_x = ?$

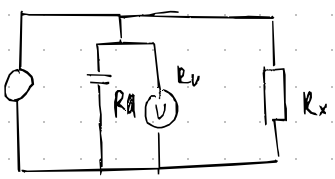



$$\frac{U_C}{U_0} = e^{-\frac{t}{RC}} / \ln \Rightarrow \ln\left(\frac{U_C}{U_0}\right) = -\frac{t}{RC}$$

$$R = \frac{-\Delta t}{C \cdot \ln\left(\frac{U_C}{U_0}\right)}$$

$$R = \frac{-22s}{100 \times 10^{-9} \cdot \ln\left(\frac{1}{2}\right)} = 317,39M\Omega$$

Kad se spoji sklopka




$$R = (R') \| (R_x) \longrightarrow \frac{R' \cdot R_x}{R' + R_x}$$

$$R' = \left(\frac{1}{R_V} + \frac{1}{R_d}\right)^{-1} = \frac{R_d \cdot R_V}{R_V + R_d}$$

$$R = \frac{\left(\frac{R_d \cdot R_V}{R_V + R_d}\right) \cdot R_x}{\frac{R_d \cdot R_V}{R_V + R_d} + R_x}$$

otpor izolacije Rd izlazi iz tangensa kuta gubitaka kondenzatora

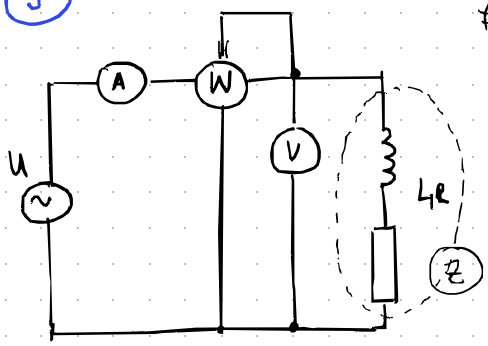
$$R_d = \frac{1}{\omega \cdot C \cdot tg\delta} = \frac{1}{2\pi f \cdot C \cdot tg\delta}$$

$R_d = 4,32G\Omega$

$$\rightarrow R' = \frac{R_d \cdot R_V}{R_V + R_d} \longrightarrow R' = 3,019G\Omega$$

$$R = \frac{R' \cdot R_x}{R' + R_x} \longrightarrow \boxed{R_x = 354,678M\Omega}$$

## 3




$f = 50\,Hz$ 1) 2) $I_A = 65\,mA$

$R_{Cu} = 245\,\Omega$ $U_V = 100\,V$

$P_W = 2{,}5\,W$

$L = ?$ $R_{Fe}$ → u mag. jezgri transformatora

$$Z_L = \frac{U_V}{I_A} = \sqrt{(\omega \cdot L)^2 + R^2}$$

→ Za nadomjesni djelatni otpor $R_L$ vrijedi $R_L = \frac{P_W}{I_A^2}$ → $R_L = 592\,\Omega$

$$\left(\frac{U_V}{I_A}\right)^2 = \omega^2 \cdot L^2 + R^2 \rightarrow \left(\frac{U_V}{I_A}\right)^2 - R^2 = \omega^2 \cdot L^2$$

$$L^2 = \frac{\left(\frac{U_V}{I_A}\right)^2 - R_L^2}{\omega^2} \rightarrow L = \frac{1}{\omega}\sqrt{\left(\frac{U_V}{I_A}\right)^2 - R_L^2}$$

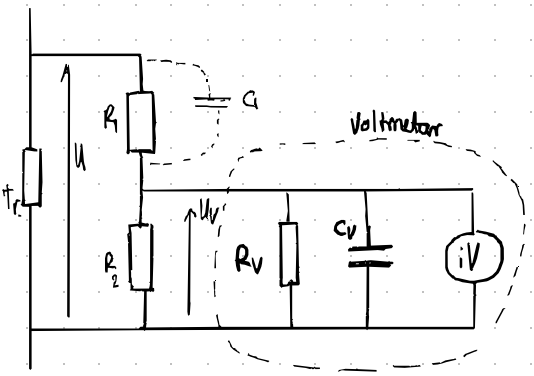
$L = 4{,}52\,H$

→ nadomjesni otpor $R_{Fe}$ gubitaka u jezgri je $R_{Fe} = R_L - R_{Cu}$ → $R_{Fe} = 347\,\Omega$

## 4

10:1 $R_V = 10\,M\Omega$ $C_V = 150\,pF$ $U = ?$

$U_V = 157{,}2\,V$ $R_G = 1{,}8\,M\Omega = R_1$ $C_1 = ?$ da se kompenzira




otporničko djelilo

$$k = 10/1 = \frac{R_1 + R_2}{R_2} = 10$$

$$\hookrightarrow = \frac{R_1}{R_2} + 1 = k$$

$$\frac{R_1}{R_2} = k - 1 \rightarrow R_2 = \frac{R_1}{k-1}$$

$R_2 = 0{,}2\,M\Omega$

da je voltmetar idealan

$U = U_V \cdot k$, ali nije → $R_2' = R_2 \parallel R_V$ → $k' = \frac{R_1 + R_2'}{R_2'}$

$$R_2' = \frac{R_2 \cdot R_V}{R_2 + R_V} \Rightarrow k' = \frac{R_1 + \frac{R_2 \cdot R_V}{R_2 + R_V}}{\frac{R_2 \cdot R_V}{R_2 + R_V}}$$

$k' = 10.18$

$\Rightarrow U' = U_V \cdot k'$

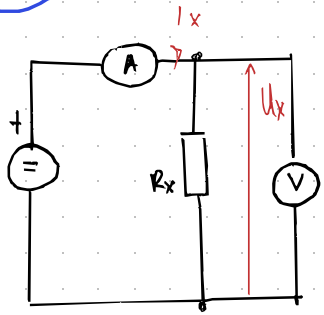
$U' = 1600{,}3\,V$

→ kompenzacija djelila za izmjenični napon => izjednačenje vremenskih konstanti donjeg i gornjeg grana

$$T_1 = T_2 \rightarrow R_1 \cdot C_1 = \frac{R_2 \cdot R_V}{R_2 + R_V} \cdot C_V$$

$$C_1 = \frac{R_2 \cdot R_V}{R_2 + R_V} \cdot \frac{C_V}{R_1} \rightarrow C_1 = 16.34\,pF$$

5.




M.O. 20V (voltmetar)

$G_1 = \pm$ (0,1 % od očitanja +0,05% M.O.)

M.O. 1.2A (ampermetar), kl. 0,5

n=10 $U_x = 15V$ $s_u = 0,02$

$I_x = 0,14A$ $s_I = 0,01$

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$R_x$, $u(R_x)$=?

$$R_x = \frac{U_x}{I_x} = \frac{15}{0,1} \rightarrow R_x = 37,5\,\Omega$$

Složene nesigurnosti

$$u(U_x) = \sqrt{u_A(U_x)^2 + u_B(U_x)^2} = 15.73mV$$

$$u(I_x) = \sqrt{u_A(I_x)^2 + u_B(I_x)^2} = 4.7mA$$

$$u_c(R_x) = \sqrt{\sum_{i=1}^{M} \left( \frac{\partial R_x}{\partial x} \cdot u(x_i) \right)^2}$$

Stand. nesigurnost ($u_A$)

$$u_A(U_x) = \frac{s_u}{\sqrt{n}} \qquad u_A(I_x) = \frac{s_I}{\sqrt{n}}$$

$u_A(U_x) = 6,32 \times 10^{-3}$ $u_A(I_x) = 3,16 \times 10^{-3}$

Stand. nesigurnost $u_B$

$$u_B = \frac{a}{\sqrt{3}} \rightarrow u_B(U_x) = \frac{G_V}{\sqrt{3}}$$

$$u_B(I_x) = \frac{kl}{100} \cdot M.O._A$$

$$\hookrightarrow u_B(U_x) = \frac{0,025}{\sqrt{3}} = 0,0144$$

$$u_B(I_x) = \frac{0,5}{100} \cdot \frac{1,2}{\sqrt{3}} = 3.46 \times 10^{-3}$$

$$\frac{\partial R_x}{\partial U_x} = \frac{1}{I_x}$$

$$\frac{\partial R_x}{\partial I_x} = U_x \cdot \left( \frac{-1}{I_x^2} \right)$$

$$\Rightarrow u_c(R_x) = \sqrt{\left( \frac{1}{I_x} \cdot u(U_x) \right)^2 + \left( \frac{-U_x}{I_x^2} \cdot u(I_x) \right)^2}$$

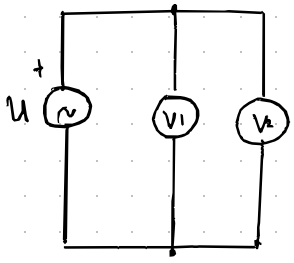
$u_c(R_x) = 0,44\,\Omega$

Mjerni rezultat zapisujemo kao: $R_x = 37,5\,\Omega$ uz $u_c(R_x) = 0,44\,\Omega$

ili $u_c(R_x)\% = \frac{u(R_x)}{R_x} = 1,17\% \rightarrow$ uz 1,17%

## 6.

! nemusmi izvor




$\mathcal{E} = ?$

$U_{V_1} = 6{,}52\,V$

$U_{V_2} = 6.16\,V$ → odziv ef. (TRMS)

$$\mathcal{E} = \frac{U}{U_{se}} = \frac{\text{efektivna (myerna)}}{\text{srednja vrijednost}}$$

↯ → bez oznake TRMS → odziv na EL. SREDNJU VR.

$\Rightarrow U_{ef} = U_{V_2}$ (jer mu je odziv na ef. vr.)

↯ pomoću $U_{V_1}$ → odredili elektrolitičku srednju vrijednost → $U_{se} = \frac{U_m}{\mathcal{E}_0} \hookrightarrow 1{,}11$

$$\Rightarrow \mathcal{E} = \frac{U_{ef}}{U_{se}} = \frac{U_{V_2}}{U_{V_1}} \cdot \mathcal{E}_0 \Rightarrow \boxed{\mathcal{E} = 1{,}05}$$

## 7.

$$u(t) = \underbrace{25{,}6 \sin(100\pi t)}_{AC_1} + \underbrace{4{,}3\sqrt{2}}_{DC} + \underbrace{11{,}2 \cos(100\pi t)}_{AC_2}$$

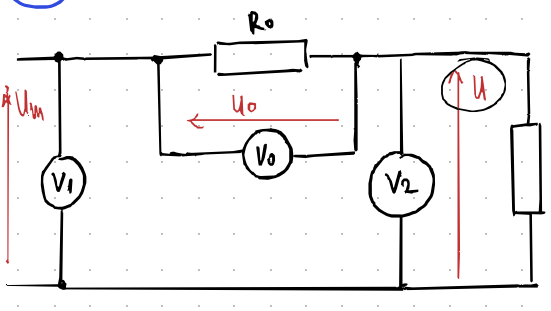
apsolutna Δ između dobivenih u oba mj. — $U_V$ (AC+DC)
$U_V$ (DC) (samo se mjeri)

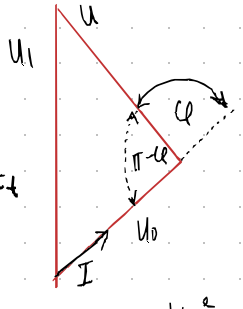
$$U = \sqrt{\left(\frac{25{,}6}{\sqrt{2}}\right)^2 + \left(4{,}3\sqrt{2}\right)^2 + \left(\frac{11{,}2}{\sqrt{2}}\right)^2}$$

$U_{AC+DC} = 20{,}67\,V$ $\quad U_{DC} = 6.08\,V$ $\longrightarrow$ $\boxed{\Delta U = 14.59\,V}$

## 8.

$Z_t = ?$




$f = 50\,Hz$ $\quad P = 95{,}6\,W$

$R_0 = 4\,\Omega$ $\quad U_0 = 3{,}7\,V$

$U_1 = 180{,}6\,V$

$Z_t = ?$

$$U_1^2 = U_0^2 + U^2 - 2UU_0\cos(\pi - \varphi)$$

$$U_1^2 = U_0^2 + U^2 + 2UU_0\cos\varphi$$

$U_0 = I \cdot R$ $\quad P = U \cdot I \cos\varphi$

$$\Rightarrow P = \frac{U_1^2 - U_0^2 - U^2}{2U_0 \cdot \cos\varphi} \cdot \frac{U_0}{R} \cdot \cos\varphi = \frac{U_1^2 - U_0^2 - U^2}{2R}$$

$$U = \sqrt{U_1^2 - U_0^2 - 2R \cdot P} = 178{,}43\,V \qquad \cos\varphi = \frac{P}{U \cdot I} = \frac{P}{U \cdot \frac{U_0}{R}} = 0{,}579$$

$$L_t = \frac{Q}{\omega \cdot I^2} = \frac{U \cdot I \cdot \sin\varphi}{\omega \cdot I^2} = \frac{U\sqrt{1 - \cos^2\varphi}}{\omega I} = \frac{U\sqrt{1 - \cos\varphi}}{2\pi f \cdot \frac{U_0}{R}} = \boxed{0{,}501\,H}$$