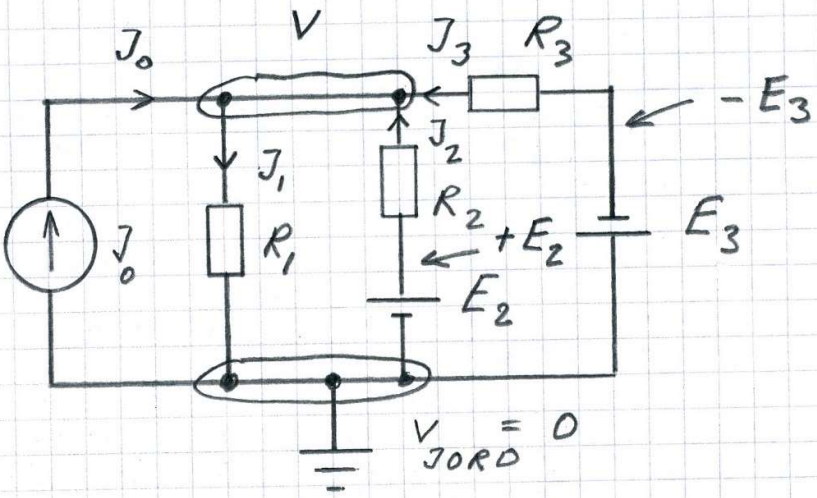
Lösningsförslag till tentamen TSFS13 Elektroteknik 2023-08-16

1. NODANALYS:



$$J_1 = \frac{V-0}{R_1} \quad \ldots (1)$$

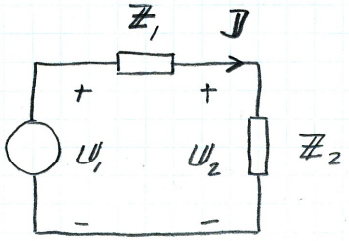
$$J_0 - J_1 + J_2 + J_3 = 0 \rightarrow$$

$$J_0 - \frac{V-0}{R_1} + \frac{E_2 - V}{R_2} + \frac{-E_3 - V}{R_3} = 0$$

$$\rightarrow V = +2{,}25\ V$$

INS. (1) $\rightarrow$ $J_1 = 1{,}5\ A$

2.



$u_1(t) = 115\sqrt{2}\,\sin(120\pi t - 0°)\ V \Rightarrow \underline{U}_1 = \underbrace{120\sqrt{2}\,e^{j0°}}_{\hat{U}_1}\ V$

$U_2 = 230\ V \Rightarrow \hat{U}_2 = 230\sqrt{2}\ V$

$$\underline{U}_2 = \underline{U}_1 \cdot \frac{\underline{Z}_2}{\underline{Z}_1 + \underline{Z}_2}$$

$$\underline{Z}_1 = \frac{1}{j\omega C} = -j\frac{1}{\omega C}$$

$$\underline{Z}_2 = R + j\omega L$$

$$|\underline{U}_2| = |\underline{U}_1| \cdot \frac{|R + j\omega L|}{\left|-j\frac{1}{\omega C} + R + j\omega L\right|}$$

$$230\sqrt{2} = 115\sqrt{2} \cdot \frac{\sqrt{20{,}0^2 + (120\pi \cdot 0{,}127)^2}}{\sqrt{20{,}0^2 + \left(120\pi \cdot 0{,}127 - \frac{1}{120\pi \cdot C}\right)^2}}$$

$$\Rightarrow \underline{C = 84{,}6\ \mu F}$$

$$I = \frac{U_2}{|\underline{Z}_2|}$$

$$I = \frac{230}{\sqrt{20{,}0^2 + (120\pi \cdot 0{,}127)^2}} \approx 4{,}43\ A$$

$$P = R \cdot I^2 \Rightarrow \underline{\underline{P = 393\ W}}$$

3a) $U_{ut} = U_Z - U_{BE} \rightarrow \underline{\underline{U_{ut} = 5{,}5\ V}}$

$U_{CE} = U_{in} - U_{ut} \Rightarrow \underline{\underline{U_{CE} = 6{,}5\ V}}$

3b) Spänningsfallet mellan plus- och minusingången på OP:n är noll.

$\rightarrow U_{R2} = U_Z$

$$U_{R2} = U_{ut} \cdot \frac{R_2}{R_1 + R_p + R_2}$$

$R_p = 0 \rightarrow$

$$3{,}3 = U_{ut} \cdot \frac{2400}{7500 + 0 + 2400} \Rightarrow U_{ut} \approx 14\ V \quad (13{,}6\ V)$$

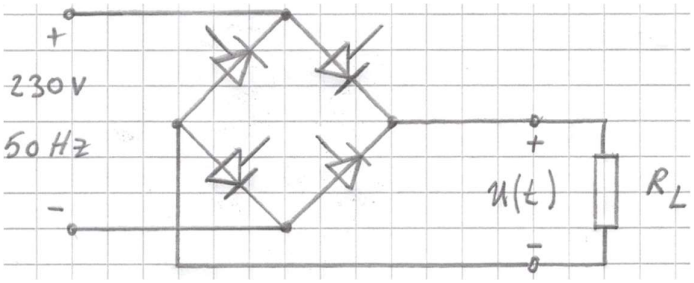
$R_p = 10\ k\Omega \Rightarrow$

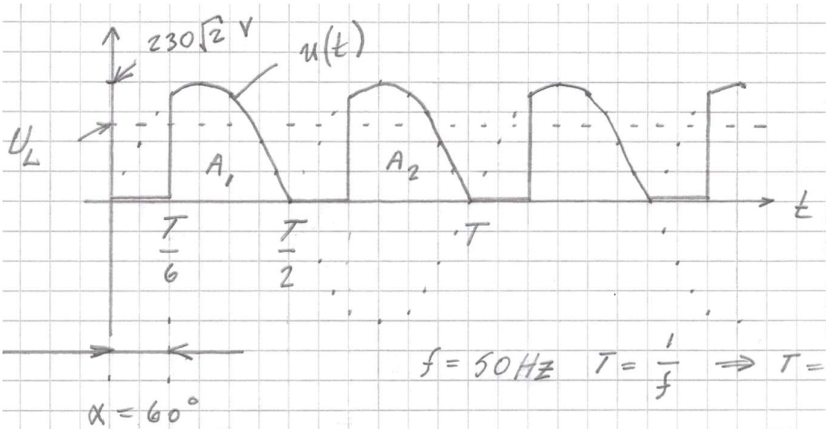
$$3{,}3 = U_{ut} \cdot \frac{2400}{7500 + 10000 + 2400} \Rightarrow U_{ut} \approx 27V \quad (27{,}4\ V)$$

ALLTSÅ $\underline{\underline{14V \lesssim U_{ut} \lesssim 27V}}$

3c) $U_{ref} = U_{ut} \cdot \frac{R_1}{R_1 + R_2} \rightarrow \underline{\underline{R_2 \approx 2{,}1\ k\Omega}}$ $(2089{,}8\ \Omega)$

4a)





$f = 50\,Hz \quad T = \frac{1}{f} \Rightarrow T = 20\,ms$

$$U_L = \frac{1}{T}\int_0^T u(t)\,dt = \left| A_1 = A_2 \right| = \frac{2}{T}\int_{T/6}^{T/2} 230\sqrt{2}\sin(\omega t)\,dt =$$

$$= \left| \omega = \frac{2\pi}{T} \rightarrow T = \frac{2\pi}{\omega} \right| = \frac{2\omega}{2\pi}\int_{\frac{\pi}{3\omega}}^{\pi/\omega} 230\sqrt{2}\sin(\omega t)\,dt =$$

$$= \frac{\cancel{2\omega}}{\pi}\cdot 230\sqrt{2}\left[\frac{-\cos(\omega t)}{\cancel{\omega}}\right]_{\frac{\pi}{3\omega}}^{\pi/\omega} =$$

$$= \frac{230\sqrt{2}}{\pi}\left[-\cos\pi + \cos\frac{\pi}{3}\right] \simeq \underline{\underline{155\ V}}$$

4b)

$\alpha = MAX\ (180°) \Rightarrow U_L = 0$

$\alpha = MIN\ (0°) \Rightarrow$

$$U_L = \frac{1}{T}\int_0^T u(t)\,dt = |A_1 = A_2| = \frac{2}{T}\int_0^{T/2} 230\sqrt{2}\sin(\omega t)\,dt =$$

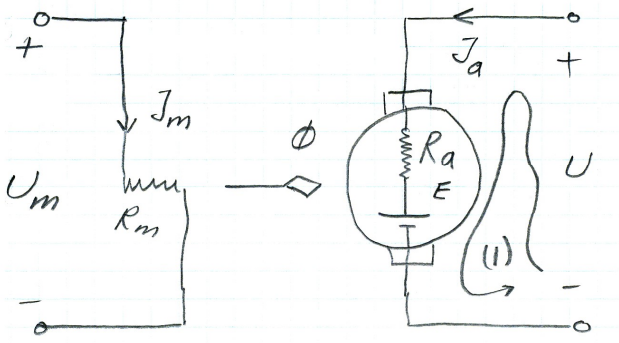
$$= \left| \omega = \frac{2\pi}{T} \Rightarrow T = \frac{2\pi}{\omega} \right| = \frac{2\omega}{2\pi}\int_0^{\frac{\pi}{\omega}} 230\sqrt{2}\sin(\omega t)\,dt =$$

$$= \frac{230\sqrt{2}\,\omega}{\pi}\left[\frac{-\cos(\omega t)}{\omega}\right]_0^{\frac{\pi}{\omega}} =$$

$$= \frac{230\sqrt{2}}{\pi}\left[-\cos\pi + \cos 0\right] \approx 207\ V$$

ALLTSÅ $\underline{0V < U_L < 207\ V}$

5.



a)

FALL I

$U_I = 250V$

$U_{mI} = 100V$

$\Phi_I = k J_{mI} = k \cdot \frac{U_{mI}}{R_m}$

$M_I = k_2 \cdot \Phi_I \cdot J_{aI}$

$J_{aI} = 20A$

$n_I = 1000$ RPM

FALL II

$U_{II} = 250V$

$U_{mII} = 80V$

$\Phi_{II} = k J_{mII} = k \cdot \frac{U_{mII}}{R_m}$

$\Rightarrow \Phi_{II} = 0,80 \cdot \Phi_I$

$M_{II} = k_2 \Phi_{II} \cdot J_{aII}$

$M_{II} = M_I \Rightarrow J_{aII} = 1,25 \cdot J_{aI} = 25A$

$n_{II} = ?$

$+ U - R_a J_a - E = 0 \ldots (1)$ DÄR $E = k_1 \Phi n$

FALL I INS I (1) $\rightarrow$

$+ 250 - 0,80 \cdot 20 - k_1 \Phi_I \cdot 1000 = 0 \Rightarrow k_1 \Phi_I = 0,234$

FALL II INS I (1) $\rightarrow$

$+ 250 - 0,80 \cdot 25 - 0,234 \cdot 0,80 \cdot n_{II} = 0$

$\Rightarrow n_{II} = 1229$ RPM

b) $\left.\begin{aligned} P_2 &= E J_a \\ P_2 &= M \cdot \frac{2\pi n}{60} \end{aligned}\right\} \rightarrow E J_a = M \cdot \frac{2\pi n}{60} \quad \ldots (2)$

FALL I INS I (2) →

$$0{,}234 \cdot 1000 \cdot 20 = M_I \cdot \frac{2\pi \cdot 1000}{60}$$

$$\Rightarrow M_I \approx 45 \text{ Nm}$$

RESULTATET BLIR DETSAMMA I FALL FALL II INS I (2) →

$$0{,}234 \cdot 0{,}80 \cdot 1229 \cdot 25 = M_{II} \cdot \frac{2\pi \cdot 1229}{60}$$

$$\Rightarrow M_{II} \approx 45 \text{ Nm}$$

ALLTSÅ: DET AKTUELLA BELASTNINGSMOMENTET ÄR $\underline{45 \text{ Nm}}$