Midterm Exam 2019 – Solutions

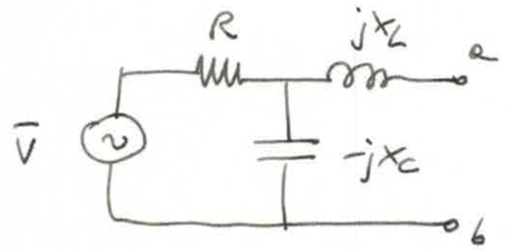
Section A

$\bar{V} = 12/\sqrt{2} \angle 0 = 8.485 \angle 0 \ V$

$R = 2500 \ \Omega$

$X_L = \omega L = 1000 \cdot 1.25 = 1250 \ \Omega$

$$X_C = \frac{1}{\omega C} = \frac{1}{1000 \cdot 2 \cdot 10^{-6}} = \frac{1}{2 \cdot 10^{-3}} = \frac{1000}{2} = 500 \ \Omega$$



(1.) $$\bar{Z}_{th} = jX_L + \frac{R(-jX_C)}{R - jX_C} = (96.15 + j\,769.23)\ \Omega$$

$$\bar{V}_{th} = \bar{V} \cdot \frac{-jX_C}{R - jX_C} = (0.326 - j\,1.6318)\ V$$

(2.) $$\bar{I}_{LOAD} = \frac{\bar{V}_{th}}{\bar{Z}_{th} + R_{LOAD}} \quad \text{where} \quad R_{LOAD} = 1000\ \Omega$$

$$\bar{I}_{LOAD} = -0.0005 - j\,0.00114 = (-0.5 - j\,1.14)\ mA$$

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Section B

3. The permeance in the air gap 1 is:

$$\mathcal{P}_1 = \frac{\mu_0 A_1}{l_1} = \frac{4 \cdot \pi \cdot 10^{-7} (0.5 \cdot 1.0) \cdot 10^{-2}}{0.1}$$

$$= 6.283 \cdot 10^{-8} \text{ H}$$

The mmf of the coil is $\mathcal{F} = Ni = 180$ A-turn,

hence:

$$\phi_1 = \mathcal{F} \mathcal{P}_1 = 180 \cdot 6.283 \cdot 10^{-8} = 1.131 \cdot 10^{-5} \text{ Wb}$$

Similarly:

$$\mathcal{P}_2 = \mu_0 A_2 / l_1 = \frac{4 \cdot \pi \cdot 10^{-7} (1.0 \cdot 1.0) 10^{-7}}{0.25}$$

$$= 5.027 \cdot 10^{-8} \text{ H}$$

$$\phi_2 = \mathcal{F} \mathcal{P}_2 = 180 \cdot 5.027 \cdot 10^{-8} = 9.048 \cdot 10^{-6} \text{ Wb}$$

4. The flux in the central column is:

$$\phi = \phi_1 + \phi_2 = \mathcal{F}(\mathcal{P}_1 + \mathcal{P}_2) = 2.036 \cdot 10^{-5} \text{ Wb}$$

5. The self-inductance of the magnetic circuit is:

$$L = N^2 (\mathcal{P}_1 + \mathcal{P}_2)$$

$$= 0.0916 \text{ H}$$

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Section C

6. $$R'_{sc} = R_1 + R_2 \left(N_1/N_2 \right)^2 = 1.56 + 0.016 \left(\frac{635}{66} \right)^2 = 3.04 \ \Omega$$

$$X'_{sc} = X_1 + X_2 \left(\frac{N_1}{N_2} \right)^2 = 4.67 + 0.048 \left(\frac{635}{66} \right)^2 = 9.12 \ \Omega$$

For the magnetizing branch $I_{10} = 0.96$

$\cos \varphi_{10} = 0.263$ (lagging)

Hence:

$$R_{Fe} = \frac{V_1}{I_{10} \cos \varphi_{10}} = \frac{6350}{0.96 \cdot 0.263} = 25.2 \ k\Omega$$

$$X_\mu = \frac{V_1}{I_{10} \sin \varphi_{10}} = \frac{6350}{0.96 \sqrt{1 - 0.263^2}} = 6.85 \ k\Omega$$

7. Full-load current $I'_2 = I_N = \dfrac{200 \cdot 10^3}{6350} = 31.5 \ A$

$$I'_2 R'_{sc} = 31.5 \cdot 3.04 = 96 \ V$$

$$I'_2 X'_{sc} = 31.5 \cdot 9.12 = 288 \ V$$

Using Kapp's formula:

p.f. = 1 $$\varepsilon_\% = \frac{V_1 - V'_2}{V_1} = \frac{96}{6350} 100 = 1.51 \%$$

p.f. = 0.8 lagging $$\varepsilon_\% = 100 \left(96 \cdot \cos\varphi + 288 \sin\varphi \right) / 6350$$
$$100 \left(96 \cdot 0.8 + 288 \cdot 0.6 \right) / 6350 = \frac{252}{6350} 100 = 3.97 \%$$

p.f. = 0.8 leading $$\varepsilon_\% = 100 \left(96 \cdot 0.8 - 288 \cdot 0.6 \right) / 6350 = \frac{-89.8}{6350} 100 = -1.41 \%$$

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EEN20090 – Midterm Examination 2018

Student Number: ______________________

Result Sheet

Question 1	$\bar{V}_{th}$ = 0,326 − j1,631 V = 1,663∠−78,7° ✓ $\bar{Z}_{th}$ = 96,1 + j770,3 Ω
Question 2	$\bar{I}_{load}$ = −0,5 − j1,135 = 1,241∠−113,8° mA
Question 3	ϕ_1 = 1,125 · 10^{-5} Wb ϕ_2 = 9,05 · 10^{-6} Wb
Question 4	ϕ = 2,03 · 10^{-5} Wb
Question 5	L = 0,09135 H
Question 6	$\bar{Z}'_{sc}$ = R_{Fe} = 25,2 kΩ X_{μ} = 6,85 kΩ
Question 7	$\epsilon_{\%}(pf=1)$ = 1,51% $\epsilon_{\%}(pf=0.8lag)$ = 3,91% $\epsilon_{\%}(pf=0.8lead)$ = −1,41%

R'_{sc} = 3,04 Ω

X'_{sc} = 9,11 Ω