

aaron bowditch exam submission

by Aaron Lee Bowditch

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Exam

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1.a) $Z_1 = X_L = 2\pi fL$

$$\begin{aligned}X_{L1} &= 2\pi \times 50 \times 120 \times 10^{-3} \\&= 12\pi \\&= 37.699 \Omega\end{aligned}$$

$Z_1 = R + jX_L$
 $= 20 + j37.699$

Z_2 $X_L = 2\pi fL$
 $= 2\pi \times 50 \times 100 \times 10^{-3}$
 $= 10\pi$
 $= 31.42 \Omega$

$Z_2 = R + jX_L$
 $= 52 + j31.42$

Z_3 $X_L = 2\pi fL$
 $= 2\pi \times 50 \times 180 \times 10^{-3}$
 $= 18\pi$
 $= 56.55 \Omega$

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi \times 50 \times 100 \times 10^{-6}} = 31.83 \Omega$$

2

$$Z_3 = R + j(X_L - X_C) \\ = 15 + j(56.55 - 31.83)$$

$$\underline{Z_3} = 15 + j25.17$$

2

$$b. I = \frac{V_L}{Z}$$

$$I_1 = \frac{V_{L1}}{Z_1} = \frac{230 \angle 0^\circ}{20 + j37.699}$$

$$= \frac{230 + j0}{20 + j37.699} \times \frac{20 - j37.699}{20 - j37.699}$$

$$= \frac{4600 - j8670.77}{400 - j753.98 + j753.98 - j^2 1421.22}$$

$$= \frac{4600 - j8670.77}{1821.22}$$

$$\underline{I_1} = \frac{4600}{1821.22} \angle -4.76^\circ \text{ A}$$

$$= 5.39 \angle -62.01^\circ \text{ A}$$

3

$$\textcircled{I_2} = \frac{V_{L2}}{Z_2}$$

$$= \frac{115 + j199.18}{52 + j31.42}$$

$$= \frac{115 + j199.18}{52 + j31.42} \times \frac{52 - j31.42}{52 - j31.42}$$

$$= \frac{5980 - j3613.3 + j10357.36 - j^2 6258.24}{2704 - j1633.84 + j1633.84 - j^2 987.22}$$

$$= \frac{12238.24 + j6744.06}{3691.22}$$

$$= 3.32 + j1.827$$

$$= 3.79 \angle 28.82^\circ \text{ A}$$

$$\textcircled{I_3} = \frac{V_{L3}}{Z_3} = \frac{115 - j199.2}{15 + j25.17}$$

$$= \frac{115 - j199.2}{15 + j25.17} \times \frac{15 - j25.17}{15 - j25.17}$$

$$= \frac{1725 - j2894.55 - j2988 + j^2 5013.86}{225 - j1525.17 + j1525.17 - j^2 633.53}$$

$$= \frac{-3288.86 - j5882.55}{858.53}$$

$$I_3 = -3.83 - j6.85 \text{ A}$$

$$= 7.84 \angle -119.21^\circ \text{ A}$$

$$I_N = I_1 + I_2 + I_3$$

$$= (2.53 - j4.76) + (3.32 + j1.827) + (-3.83 - j6.85)$$

$$= 2.02 - j9.783 \text{ A}$$

$$= 9.99 \angle -78.33^\circ \text{ A}$$

d. Active power

$$P_1 = I^2 R$$

$$= (2.53 - j4.76)^2 (20 + j37.699)$$

$$= (2.53 - j4.76)(2.53 - j4.76)$$

$$= 6.4 - j12.04 - j12.04 + j^2 22.66$$

$$= (-16.26 - j24.08) \times (20 + j37.699)$$

$$= -325.2 - j612.99 - j481.6 - j^2 907.79$$

$$= 582.59 - j1094.59$$

d. $P = \frac{V_1^2}{R} = \frac{230^2}{20} = \underline{2645 \text{ W}}$

$P_2 = \frac{V_2^2}{R} = \frac{230^2}{52} = \underline{1017.31 \text{ W}}$

$P_3 = \frac{V_3^2}{R} = \frac{230^2}{15} = \underline{3526.6 \text{ W}}$

$S_1 = VI$
 $= 230 \times 5.39$
 $= \underline{1239.7 \text{ VA}}$

$S_2 = 230 \times 3.79$
 $= \underline{871.7 \text{ VA}}$

$S_3 = 230 \times 7.84$
 $= \underline{1803.2 \text{ VA}}$

e

~~$Q_1 = \sqrt{2645^2 - 1239.7^2}$~~

~~$Q = \sqrt{2645^2 - 1239.7^2}$~~

$Q_1 = \sqrt{2645^2 - 1239.7^2} = \underline{2336.48 \text{ VAR}}$

$Q_2 = \sqrt{1017^2 - 871.7^2} = \underline{523.86 \text{ VAR}}$

$Q_3 = \sqrt{3526.6^2 - 1803.2^2} = \underline{3027.25 \text{ VAR}}$

g) $Pf = \frac{S}{P}$

$Pf_1 = \frac{1239.7}{2645} = \underline{0.47}$

$Pf_2 = \frac{871.7}{1017.31} = \underline{0.86}$

$Pf_3 = \frac{1803.2}{3526.6} = \underline{0.51}$

⑥

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Q2 answer

Advantages and disadvantages of local versus central power factor correction

Advantages of power factor correction;

- Reduces demand charge
- Increases load carrying abilities of already existing circuits
- Improves voltage as higher power factor means less current flowing
- Reduces carbon footprint as it allows for less strain on the power grid
- Reduces voltage drops in system by installing capacitors
- Increases available power
- Can reduce installation size as wires carry less current meaning smaller wires

Local power factor correction

Local power factor correction is done on site at the load end, this means that any power loss or phase difference which is present during transmission will not affect the power at the load if correction is done locally.

Advantages;

- can be customised to suit specific machines
- less components than central power factor

disadvantages;

- correction is required for all loads
- can be costly to correct all loads

Power factor correction done centrally can mean that the source to load is balanced, although some imbalances may happen along transmission which would still require correction once reaching a load.

Advantages;



- central correction can allow all loads to be corrected at source
- easier to manage and maintain than local correction on separate loads.

Disadvantages;

- a large correction system will be needed
- may need altering when different loads are switched on
- large system required at central source to allow for full correction.

⑦

$$3a) \frac{V_{LP}}{V_{LS}} = \sqrt{3} \frac{V_{PP}}{V_{PS}} = \sqrt{3} \frac{N_P}{N_S}$$

$$V_{LS} = \frac{V_{LP}}{n\sqrt{3}} = \frac{132000}{15 \times \sqrt{3}} = \underline{5080.68 \text{ V}}$$

$$\frac{I_{LP}}{I_{LS}} = \frac{I_{PP}}{\sqrt{3}} \times \frac{1}{I_{PS}}$$

$$= \frac{1}{\sqrt{3}} \times \frac{N_S}{N_P}$$

$$I_{LS} = \sqrt{3} \times 15 \times I_{Lprime}$$

$$= \sqrt{3} \times 15 \times 170$$

$$= \underline{4416.73 \text{ A}}$$

$$3b) \frac{V_{PP}}{V_{PS}} = \frac{N_P}{N_S}$$

$$\frac{V_{LP}}{V_{LS}} = V_{PS} \times \frac{V_{PP}}{\sqrt{3}} = \frac{1}{\sqrt{3}} \times \frac{N_S}{N_P}$$

$$V_{LS} = \sqrt{3} \times \frac{V_{LP}}{n} = \sqrt{3} \times \frac{132000}{15} = \underline{15242.047 \text{ V}}$$

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$$\frac{I_{PP}}{I_{PS}} = \frac{N_S}{N_P}$$

$$\frac{I_{LP}}{I_{LS}} = \frac{I_{PP}}{I_{PS}} \times \sqrt{3} = \frac{N_S}{N_P} \times \sqrt{3} = \frac{\sqrt{3}}{15}$$

$$I_{LS} = \frac{15}{\sqrt{3}} \times I_{LP} = \frac{15}{\sqrt{3}} \times 170 = \underline{1472.24 A}$$

$$\begin{aligned} S &= V_{LL} \times I_{LS} \\ &= 15242.047 \times 1472.24 \\ &= \underline{22.4 \text{ MVA}} \end{aligned}$$

3A POWER

$$\begin{aligned} S &= V_{LS} \times I_{LS} \\ &= 5080.68 \times \cancel{4416.73} \times 4416.73 \\ &= \underline{22.4 \text{ MVA}} \end{aligned}$$

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$$41) B_{core} = \frac{\Phi}{A} = \frac{560 \times 10^{-6}}{40 \times 10^{-3} \times 100 \times 10^{-3}}$$
$$= \frac{560 \times 10^{-6}}{4 \times 10^{-3}} = 0.14 \text{ T}$$

$$H = 2142.857$$

$$\text{mmf}_{core} = H \times L$$
$$= 2142.857 \times 650 \times 10^{-3}$$
$$= 1392.86 \text{ At}$$

$$B_{airgap} = B_{core} = 0.14 \text{ T}$$

$$\text{mmf}_{gap} = \frac{0.14}{\mu_0} = \frac{0.14}{4\pi \times 10^{-7}} = 111408.46$$

$$\text{mmf}_{Total} = \text{mmf}_{core} + \text{mmf}_{gap}$$
$$= 1392.86 + 111408.46$$
$$= 112801.32 \text{ At}$$

$$I = \frac{\text{mmf} T}{N} = \frac{112801.32}{1200} = 94.01 \text{ A}$$

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GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

67/100

PAGE 1



Comment 1

Q1a - 4 Marks

Q1b - 7 Marks

Q1c - 4 Marks

Q1d - 0 Marks

Q1e - 3 Marks

Q1f - 3 Marks

Q1g - 3 Marks

Q1h - 0 Marks

Q1 Total - 24 Marks

Q2. 9 Marks

Q3a - 10 Marks

Q3b- 10 Marks

Q4 - 7 Marks

Total 60/90 = 67%

PAGE 2



Comment 2

Q1a -4 Marks

Z1 Correct - 2 Marks

Z2 incorrect - the components are in parallel - needed to use product over sum - 0.5 Marks for inductor value

Z3 incorrect - All correct until last line. $56.55 - 31.83$ is not 25.17 . - 1.5 Marks



Comment 3

I1 correct - 3 Marks

PAGE 3



Comment 4

I2 - Correct magnitude, incorrect angle.

Sign Error

Problem is from first divide. voltage should be $-115 + j199.18$ not $+115 + j199.18$.

- 2 Marks

PAGE 4



Comment 5

I3 - Same error as I2. Sign issue on voltage,

2 Marks



Comment 6

Q1b - 7 Marks



Comment 7

Q1c - Correct 4 Marks

PAGE 5



Comment 8

Q1d) Active power.

Can't use V^2/R as the resistive part of load doesn't have all the voltage across it - remember its a series circuit.

0 Marks



Comment 9

Q1f) apparent power

Correct

3 Marks



Comment 10

Q1e) Reactive Power

Error from Q1d Carried Forward

Correct

3 Marks

PAGE 6



Comment 11

Q1g) Power Factor

Correct

PAGE 7



Comment 12

Discussion of advantages and disadvantages 9 Marks.

10 marks lost as no Examples given

PAGE 8

PAGE 9



Comment 13

Q3a) 10 Marks

Q3b) 10 Marks

PAGE 10



Comment 14

You have used μ instead of calculated H



Comment 15

You've only calculated H in the air gap and not the mmf. You forgot to multiply by the length of the air gap.



Comment 16

Almost the right method. Several mistakes along the way.

7 Marks