

Exam

by Andrew Kyle Hart

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Electrical Engineering

Online Exam

ACDA5001



Start time 11:00

Finish time 13:00

Duration: 2 Hours

Friday 22nd January 2021

Andrew Hart

23/1/21

ELECTRICAL ENGINEERING EXAM

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1a) Z_1 20Ω 120mH

$$X_L = 2\pi fL$$
$$= 2\pi(50)(120 \times 10^{-3})$$
$$X_L = 37.699\Omega$$

$$Z_1 = 20 + j37.699$$

Z_2 52Ω 100mH

$$X_L = 2\pi fL$$
$$= 2\pi(50)(100 \times 10^{-3})$$
$$X_L = 31.416\Omega$$

$$Z_2 = 52\Omega + j31.416$$

Z_3 15Ω 180mH $100\mu\text{F}$

$$X_L = 2\pi fL$$
$$= 2\pi(50)(180 \times 10^{-3})$$
$$= 56.549\Omega$$

$$X_C = 1/2\pi fC$$
$$= 1/2\pi(50)(100 \times 10^{-6})$$
$$= 1/0.0314$$
$$= 31.830\Omega$$

$$X_L + X_C = 56.549 + 31.830$$
$$= 88.379\Omega$$

$$Z_3 = 15 + j88.379$$

(2)

$$b) I_1 = \frac{V_{L1}}{Z_1} = \frac{230 \angle 0^\circ}{20 + j37.699} \rightarrow \text{RECTANGLE} \frac{230 + j0}{20 + j37.699}$$

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

$$\frac{4600 - j8670.77}{400 - j753.98 + j753.98 - j^2 1421.215}$$

$$\frac{4600 - j8670.77}{1821.215}$$

$$= 2.526 - j4.761 \text{ A}$$

$$|I_1| = 5.39 \angle -62.05^\circ$$

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$$I_2 = \frac{V_{L2}}{Z_2} = \frac{230 \angle 120^\circ}{52 + j31.416} = \frac{-115 + j199.186}{52 + j31.416}$$

$$\frac{-115 + j199.186}{52 + j31.416} \times \frac{52 - j31.416}{52 - j31.416}$$

$$\frac{-5980 + j3612.84 + j10357.672 - j^2 6257.627}{2704 - j1633.632 + j1633.632 - j^2 986.965}$$

$$= \frac{277.627 + j13970.512}{3690}$$

$$= 0.0752 + j3.786$$

$$|I_2| = 3.787 \angle 88.86^\circ$$

6

5

$$I_3 = \frac{V_3}{Z_3} = \frac{230 \angle 240^\circ}{15 + j88.379} = \frac{-1.5 - j199.186}{15 + j88.379}$$

$$\frac{-1.5 - j199.186}{15 + j88.379} \times \frac{15 - j88.379}{15 - j88.379}$$

$$\frac{-1725 + j10163.585 - j2987.79 + j^2 17603.859}{225 - j1325.685 + j1325.685 - j^2 7810.848}$$

$$= \frac{-19328.859 + j7175.795}{8035.848}$$

$$= -2.405 + j0.893$$

$$|I_3| = 2.565 \angle 159.63^\circ$$

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c) $I_d = I_1 + I_2 + I_3$

$$2.526 - j4.761 + 0.075 + j3.786 - 2.405 + j0.893$$

$$= 0.196 - j0.082$$

$$|I_d| = 212.46 \text{ mA} \angle -22.70^\circ \text{ or } 0.212 \angle -22.70^\circ \text{ A}$$

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(4)

c) P_1

$$Z_1 = 20 + j37.69$$

$$I_1 = 2.526 - j4.761 \rightarrow 5.39 \angle -62.05^\circ$$

$$P_1 = I^2 R = 5.39^2 \times 20 = 581.042 \text{ W}$$

P_2

$$Z_2 = 52 \angle 2 + j31.416$$

$$I_2 = 0.0752 + j3.786 \rightarrow 3.787 \angle 88.86^\circ$$

$$P_2 = I^2 R = 3.787^2 \times 52 = 745.751 \text{ W}$$

P_3

$$Z_3 = 15 + j88.379$$

$$I_3 = 2.405 + j0.893 \rightarrow 2.565 \angle 159.63^\circ$$

$$P_3 = I^2 R = 2.565^2 \times 15 = 98.688 \text{ W}$$

d) Q_1

$$Q = I^2 X = 5.39^2 \times 37.69 = 1094.974 \text{ VAR}$$

Q_2

$$Q = I^2 X = 3.787^2 \times 31.416 = 450.548 \text{ VAR}$$

Q_3

$$Q = I^2 X = 2.565^2 \times 88.379 = 581.465 \text{ VAR}$$

5

f) S_1
 $S = \sqrt{Q^2 + P^2} = \sqrt{1094.974^2 + 581.042^2} = 1239.588 \text{ VA}$
 S_2
 $S = \sqrt{Q^2 + P^2} = \sqrt{450.548^2 + 745.751^2} = 871.285 \text{ VA}$
 S_3
 $S = \sqrt{Q^2 + P^2} = \sqrt{581.465^2 + 98.688^2} = 589.780 \text{ VA}$

g) PF_1
 $\phi = \tan^{-1} Q/P_1 = \tan^{-1} 1.8865 = 62.047$
 $PF_1 = \cos 62.047$
 $PF = 0.469$

PF_2
 $\phi = \tan^{-1} Q_2/P_2 = \tan^{-1} 0.641 = 31.138$
 $PF_2 = \cos 31.138$
 $PF_2 = 0.856$

PF_3
 $\phi = \tan^{-1} Q_3/P_3 = \tan^{-1} 5.891 = 80.367$
 $PF_3 = \cos 80.367$
 $PF_3 = 0.167$

h) CAP
 $\phi_{NEW} = \cos^{-1} PF = \cos^{-1} 0.95 = 18.195$
 $Q_{NEW} = P \times \tan \phi_{NEW} = 581.042 \times \tan 18.195$
 $= 190.981 \text{ VAR}$
 $X_C = V^2 / Q_{NEW} = 230^2 / 190.981 = 276.991 \Omega$
 $C = 1 / 2\pi(50)(276.991) = 11.492 \mu F$
 $Q_{CAP} = Q - Q_{NEW} = 1094.974 - 190.981 = 903.993$
 $X_C = V^2 / Q_{CAP} = 230^2 / 903.993 = 58.518 \Omega$
 $C = 1 / 2\pi(50)(58.518) = 54.395 \mu F$

(6)

CAP₂

$$Q_{NEW} = P \times \tan \phi_{NEW} = 745.751 \times \tan 18.195 \\ = 245.118 \text{ VAR}$$

$$Q_{CAP_2} = Q - Q_{NEW} = 450.548 - 245.118 = 205.43$$

$$X_C = V^2 / Q_{CAP_2} = 230^2 / 205.43 = 257.509 \Omega$$

$$C = 1 / 2\pi(50)(257.509) = 12.361 \mu\text{F}$$

CAP₃

$$Q_{NEW} = P \times \tan \phi_{NEW} = 98.688 \times \tan 18.195 \\ = 32.437 \text{ VAR}$$

$$Q_{CAP} = Q - Q_{NEW} = 581.465 - 32.437 = 549.028$$

$$X_C = V^2 / Q_{CAP_3} = 230^2 / 549.028 = 96.352 \Omega$$

$$C = 1 / 2\pi(50)(96.352) = 33.036 \mu\text{F}$$

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Q. THERE ARE TWO WAYS TO APPLY POWER FACTOR CORRECTION TO A LOAD. LOCAL CORRECTION IS HAVING A CORRECTIVE CAPACITOR DIRECTLY CONNECTED TO EACH INDIVIDUAL LOAD. EG. A CAPACITOR COULD BE CONNECTED ACROSS THE TERMINALS OF A MOTOR. CENTRAL CORRECTION IS HAVING ONE BANK OF CORRECTIVE CAPACITORS CONNECTED IN THE MAIN DISTRIBUTION CENTRE OR IN A SUBSTATION.

LOCAL CORRECTION IS BEST SUITED TO WORK WITH LOADS THAT ARE ACTIVE FOR GREAT PERIODS OF TIME AND ~~LARGE~~^{SMALLER} NUMBER OF LOADS. THE ADVANTAGES OF THIS IS THAT IT IS A SIMPLE SOLUTION THAT IS CONNECTED DIRECTLY TO THE LOADS. HOWEVER, THIS METHOD WOULD BE UNECONOMICAL FOR A LARGE AMOUNT OF LOADS THAT ARE NOT CONSTANTLY OPERATING. FOR SUCH CASES WHEN LOADS NUMBERS ARE GREAT AND RUN TIME IS NOT CONSTANT CENTRAL CORRECTION IS MUCH MORE EFFICIENT. HAVING TO CONNECT LOCAL CORRECTIVE CAPACITORS TO A LARGE AMOUNT OF LOADS WILL BE EXPENSIVE.

TO SUMMARIZE

LOCAL CORRECTION - BEST FOR LOW NUMBER OF LOADS THAT RUN CONSTANTLY

CENTRAL CORRECTION - BEST FOR HIGH NUMBER OF LOADS WITH VARIATION IN RUN TIME.

8

Q3. 132KV 170A 15:1

$$a. I_{LINE S} = \frac{1}{\sqrt{3}} \times \frac{NP}{NS} \times I_{LINE P} =$$

$$= 15 \times \frac{1}{\sqrt{3}} \times 170 = 4416.73A$$

BY EW

$$V_{LINE S} = \frac{V_{LINE P}}{N/\sqrt{3}} = \frac{132000}{15/\sqrt{3}} = 5080.682V$$

$$S = V_{LINE S} \times I_{LINE S} = 5080.682 \times 4416.73A \\ = 22.44 \text{ MVA}$$

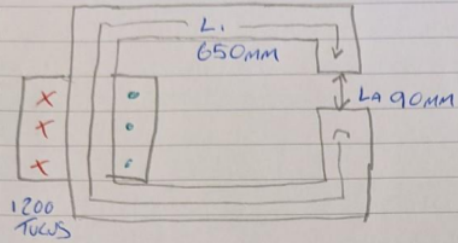
$$b. V_{LINE S} = \sqrt{3} \times \frac{V_{LINE P}}{NP} = \frac{\sqrt{3} \times 132000}{15} = 15242.047V$$

$$I_{LINE S} = \frac{15}{\sqrt{3}} \times I_{LINE P} = \frac{15}{\sqrt{3}} \times 170 = 1472.243A.$$

$$S = V_{LINE S} \times I_{LINE S} = 15242.047 \times 1472.243 \\ = 22.44 \text{ MVA.}$$

Q

Q4



$$\mu_{\text{eff}} = 2142.857 \text{ H/m}$$

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

$$B\text{-H CURVE} \quad H = 300 \text{ A/m}$$

$$\text{MMF}_{\text{core}} = H \times L = 300 \times 650 \times 10^{-3} \\ = 195$$

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

Exam

GRADEMARK REPORT

FINAL GRADE

83/100

GENERAL COMMENTS

Instructor

Q1a) 4 Marks

Q1b) $3+3+3 = 9$

Q1c) 4 Marks

Q1d) 3 Marks

Q1e) 3 Marks

Q1f) 3 Marks

Q1g) 3 Marks

Q1h) $3+2+2 = 7$

Q2) 14

Q3a) 10

Q3b) 10

Q4) 5

Total $75/90 = 83.3\%$

PAGE 1



Comment 1

Q1a) 4 Marks

Q1b) $3+3+3 = 9$

Q1c) 4 Marks

Q1d) 3 Marks

Q1e) 3 Marks

Q1f) 3 Marks

Q1g) 3 Marks

Q1h) $3+2+2 = 7$

Q2) 14

Q3a) 10

Q3b) 10

Q4) 5

Total $75/90 = 83.3\%$

PAGE 2



Comment 2

These should be in parallel. Use product over sum.



Comment 3

Capacitive reactance should always be subtracted from inductive reactance not added.



Comment 4

Q1a)

Phase 1 2 Marks

Phase 2 - 1 Mark

Phase 3 - 1 Mark

total 4 Marks

PAGE 3



Comment 5

Q1b) Phase 1 -

Correct

3 Marks



Comment 6

Q1b)
Phase 2 Correct
3 Marks

PAGE 4



Comment 7

Q1b)
Phase 3 Correct
3 Marks



Comment 8

Q1c) correct
4 Marks

PAGE 5



Comment 9

Q1d) Correct
3 Marks



Comment 10

Q1e) Correct
3 Marks

PAGE 6



Comment 11

Q1f) Correct
3 Marks



Comment 12

Q1g) Correct
3 Marks

PAGE 7



Comment 13

Q1h)

Phase 1 Correct - 3 Marks

Phase 2 incorrect - 2 Marks

Phase 3 incorrect - 2 Marks

PAGE 8



Comment 14

Q2

Discussion of advantages & Disadvantages - 4 Marks

Example of situations - 10 Marks

Q2 total - 14 Marks

PAGE 9



Comment 15

Q3a) 10 Marks

Q3b) 10 Marks

PAGE 10



Comment 16

Q4) 5 Marks

Incomplete answer