Examination Rules

1. All books, notes, and personal items (with the exception of pencils, eraser, eight sheets of unmarked scratch paper, and ladies’ purses) must be left in the back of the room.

2. The examination is Closed Book, Closed Note, and Closed Reference.

3. **All problems will be graded on correct answer only.**

4. Answers **must** be placed in the indicated space for a problem to be eligible for grading.

5. The examination **must** be submitted to the examination proctor prior to 4:00 pm to be graded.

6. Academic misconduct (i.e. plagiarism or cheating) will **not be tolerated**. Any suspected instance of academic misconduct will be investigated thoroughly. Any student involved in academic misconduct will be prosecuted to the full extent allowed under university policy. This penalty will include an automatic grade of “F” in the course without the opportunity for withdrawal. If the offense is the second offense at UAB, permanent dismissal from UAB will result.

7. No student may leave their seat without the permission of the examination proctor unless in the process of submitting the examination for grading and leaving the room.

I have read and understand the above stated examination rules.

Signature

SOLUTION KEY

PRINTED NAME (FIRST/ M.I./LAST)
A balanced, positive (abc) sequenced, 60 Hz, three-phase system has a voltage at the loads of 120 volts, line-to-neutral. It serves the following loads:

\[ V_a \]

Load 1: Delta-Connected, \( S_T = 25000 / 45^\circ \text{ VA} \)
Load 2: WYE-Connected, \( S_T = 2000 / -10^\circ \text{ VA} \)
Load 3: Delta-Connected, \( Z_A = 9+j6 \text{ Ohms} \)

\[ \frac{1}{3} S_3 = V_{ph} I_{ph}^* = \frac{|V|}{jX_p} \quad S_3 = 11981.5 / 33.7^\circ \]

(10 points) What is the total complex power consumed by the loads?

\[ S_T = 38105.3 + 38.99^\circ \text{ (Volt-Amperes)} \]

(10 points) What is the power factor of the total load?

\[ 0.777 \quad \text{(leading lagging)} = \cos (38.99^\circ) \]

(10 points) If this entire load were replaced with a single WYE-Connected impedance, what value would that impedance have?

\[ S_\phi = \frac{S_T}{3} = 12701.8 + 38.99^\circ \]

\[ Z_Y = 1.1337 / 38.99^\circ \text{ (Ohms)} \]

\[ Z_\gamma = \frac{|V|}{|S_\phi|^*} \]

(10 points) A load is to be placed at the load to correct the total power factor to 0.9. What reactive power should be consumed by this load?

\[ S_T = 9632.51 - 90^\circ \text{ (Volt-Amperes)} \]

(10 points) What Delta-connected reactance should the power-factor correcting load have?

\[ Z_A = 13.4541 - 90^\circ \text{ (Ohms)} \]

\[ Z_\Delta = 3 Z_\gamma \]

(10 points) What component value should the Delta-connected power-factor-correcting load have?

\[ 197 \mu \text{ (Farads Henries)} \]

\[ |Z_c| = \left| \frac{1}{j\omega c} \right| \]

\[ \omega = 2\pi (60 \text{ Hz}) \approx 377 \]
Power Factor Correction

Par Phase:

\[ S_{\text{OLD}} = \left( \frac{38105.31 + 38.99^\circ}{\sqrt{3}} \right) = 9872.2 + j7992.2 \]

New power factor = 0.9

Same real power for corrected load

\[ \frac{P_{\text{New}}}{|S_{\text{New}}|} = 0.9 \rightarrow |S_{\text{New}}| = 10969.1 \]

\[ \theta_{\text{New}} = \cos^{-1}(0.9) = 25.84^\circ \]

\[ S_{\text{New}} = 10969.1 \angle 25.84^\circ = 9872.2 + j4781.3 \]

\[ S_{\text{OLD}} + S_{\text{FIX}} = S_{\text{NEW}} \rightarrow S_{\text{FIX}} = S_{\text{NEW}} - S_{\text{OLD}} \]

\[ S_{\text{NEW}} = 9872.2 + j4781.3 \]

\[ - S_{\text{OLD}} = 9872.2 + j7992.2 \]

\[ S_{\text{FIX}} = 0 - j3210.1 \]

Total Complex Power for Power-Factor-Correcting Load:

\[ S_T = 3S_0 = 96301 -90^\circ \]

\[ S_{\text{OLD}} \quad \text{S}_{\text{NEW}} \quad \text{S}_{\text{FIX}} \]

\[ 7992 \quad 4781 \quad 9872 \]
A balanced, positive (abc) sequenced, 60 Hz, three-phase system serves the following loads:

Load 1: WYE-Connected, $Z_Y = 0.9 + j0.6$ Ohms
Load 2: Delta-Connected, $Z_A = 0.7 + j0.7$ Ohms
Load 3: Delta-Connected, $Z_A = 0.5$ Ohms

The Transmission Line impedance is $0.3 + j0.2$ Ohms.

At the load, $V_{AN} = 240 / 30^\circ$

$$Z_{Y_T} = Z_Y / Z_{R_2} / Z_{R_3}$$

$$Z_L = 0.107534 / 16.59^\circ$$

The source produces a different voltage to overcome the voltage loss in the transmission lines, so that the load has the rated voltage. Compute the following values:

(5 points) $V_{bn} = 1036.5 / -76.8^\circ$ (Volts)

(5 points) $V_{ab} = 1795.3 / 73.2^\circ$ (Volts)

(10 points) $I_{aA} = 2231.8 / 13.41^\circ$ (Amps) = $\frac{V_{AN}}{Z_{Y_T}}$ $\{ See \ Below \}$

What is the total power output of the source?

(10 points) $S_T = 6939782 / 29.78^\circ$ (Volt-Amps) = 3 $(I_{aA}^* \cdot V_{an})$

What is the total power consumed by the load?

(10 points) $S_T = 1606.928 / 16.6^\circ$ (Volt-Amps) = 3 $(I_{aA}^* \cdot V_{AN})$

$$V_{AN} = \left( \frac{Z_L + Z_{Y_T}}{Z_{Y_T}} \right) V_{AN}$$

$$= [4.3187 / 13.19^\circ] V_{AN}$$

$$= 1036.5 / 43.2^\circ$$

$$V_{bn} = [1 / -120^\circ] V_{aA} = 1036.5 / -76.8^\circ$$

$$V_{ab} = [\sqrt{3} / 30^\circ] V_{an} = 1795.3 / 73.2^\circ$$