Portland State University

Electrical & Computer Engineering
EE 347 Power Systems I

-Midterm Exam (Practice)-

Students have 110 minutes to complete this exam. Write neatly, box answers, and show all calculations. This is an open-book, open-note exam. No assistance from any other person shall be solicited or accepted.

This is exclusively an open-book, open-note exam. Students may refer to their own course notes and assignments. Students may use any of the texts listed in the course syllabus. However, students shall not refer to any other sources.

Students may use a calculator. No other means of calculation, such as Matlab, MathCAD, etc., are permitted.

This exam consists of four problems, each worth 25 points. Write neatly, box answers, and show all calculations. It is imperative to ensure student work is legible; illegible work will receive no credit.

All work must be done within the pages provided in this file; no additional pages may be amended. This coversheet shall accompany the submission.

Please sign below acknowledging acceptance of these terms.

Student name, printed: ________________________

Student Signature: ________________________

Start Time: _______ End Time: _______

Problem 1: _______

Problem 2: _______

Problem 3: _______

Problem 4: _______

Total: _______

Problem 1 (25 points)

A food-services company with a 480 V, three-phase service entrance has the following set of loads:

- A 6 ton walk-in refrigeration unit:[1] COP of 2.1 and 0.78 lagging power factor
- A conveyor belt system consisting of 7 continuous-duty induction motors: each 3 HP, 88% efficient, PF = 0.79 lagging
- A 18 kVA T8 fluorescent lighting system with electronic ballasting, 0.93 leading PF.
- A 65,000 BTU/hr food dehydrator[2]

Consider the case when all systems are fully loaded. Calculate the reactive power required to compensate this customer's load to a 0.92 lagging power factor.

[1] 1 ton of refrigeration = 3.517 kW. COP = η/100%

[2] 1 kW = 3.4 kBTU/hr

Problem 2 (25 points)

A three-phase, variable-frequency drive (VFD) draws lagging non-sinusoidal line current, resulting in significant waveform distortion. The VFD is connected to a 480 V service and draws 12 kW.

Spectral analysis of the current reveals the following:

Table 1 Harmonic RMS line current magnitudes

N	I_{RMS} (A)
1	15
3	7
5	4
7	2
9	1

a. Calculate the THD of the current waveform[3].

b. Calculate the Displacement power factor.

c. Calculate the True power factor.

[3] IEEE 519.1992 THD definition

Problem 3 (25 points)

A 60 Hz, pad-mount three-phase transformer for an off-shore wind turbine must be designed to handle 7.2 MVA and have a bank ratio of 600 V-34.5 kV.

The transformer shall be built using three 60 Hz single-phase transformers. Specify the high and low side voltages, rated power, rated coil currents, and the turns ratio of these transformers if they are to be connected in a Δ-Wye configuration. The transformer bank shall be grounded.

Draw a circuit diagram showing this configuration.

Problem 4 (25 points)

Open-circuit and short-circuit tests were performed under rated conditions on the primary side of a 375 kVA, single-phase 7.2k-277 V distribution transformer[4]. Test data are presented in Table 1. The transformer is load regulated.

a. Determine the primary-side cantilever equivalent circuit for the transformer.
b. Determine the transformer voltage regulation (load regulated) under full load with a 0.85 lagging PF.

Table 2 Short-circuit and open-circuit test data

Open-Circuit Test Data	**Short-Circuit Test Data**
I_{OC} = 22 A	V_{SC} = 360 V
P_{OC} = 8.5 kW	P_{SC} = 7.5 kW

[4] Designed for a 12.47kV-120/240V step down service.