Portland State University
Electrical & Computer Engineering
EE 347 Power Systems I

- Lab 2: Power Factor Correction -

Introduction
For this lab, students use capacitor banks to correct the power factor of a three-phase inductive load. Students learn how power factor correction changes line current magnitude through reduction of reactive power transfer from source to load. Students also design and demonstrate a power factor correction function that returns the capacitive reactance required to correct an inductive load over a constrained range of real and reactive load values.

Objectives
Students learn how capacitors are used to correct the power factor of an inductive load. As capacitive reactance is added to a load bus, students should observe

- the load power factor angle shift
- a change in the reactive power provided by the power supply
- a change in the line current magnitude serving the load

Data analysis and interpretation, drawing conclusions
Design a power factor correction function that calculates required reactive power for a given load

Part 1: Circuit Build and Data Gathering

The GTA will demonstrate how the power factor of an inductive load can be adjusted by adding capacitive reactance to the load bus.

Follow the lock-out/tag-out start-up and shut-down procedures.

Build two Wye-connected load with the following impedances:

$$\text{Case 1: } \mathbf{Z_L} = 600\ \Omega$$
$$\text{Case 2: } \mathbf{Z_L} = 300 + j300\ \Omega$$

Connect the loads to the 120/208 VAC power supply.

For each case, add a parallel, Wye-connected capacitor bank, and sweep through a series of capacitive impedances:

$$X_C = -[171, 200, 240, 300, 400, 600, 1200, \text{open}]\ \Omega.$$

Use the LVDACS meters, oscilloscope, and phasor analyzer to demonstrate how X_C affects the power factor angle, reactive power, and line current. Record these data from the meters.

Part 2. Data Analysis and Interpretation, Drawing Conclusions

2.1 Calculations, Analysis & Discussion

Calculate $\mathbf{S_L}$ for each case.
Calculate the range of Qc.
Calculate all expected $\mathbf{S_{Total}}$, and $\mathbf{I_{line}}$.

Analyze how $\mathbf{V_{bus}}$, $\mathbf{I_{line}}$, PF, Θ, P_{Total}, and Q_{Total} vary as a function of Q_C. Discuss findings; does the analysis agree with the theory as discussed in lecture? Compare calculations to observations and explain discrepancies.

2.2 Engineering Design

Design a power factor correction function that calculates required reactive power for a given load according to the following specifications.

1. The function shall be written using either Matlab or Python
2. The function arguments shall be

$$\mathbf{S_{Load}} = P_L + jQ_L = [1+j0:10+j10] \text{ MVA}$$

exclusive of $|\mathbf{S_{Load}}| > 10$ MVA.

3. The function shall return the capacitance, Q_C, required to maintain

$$0.95 \text{ lagging} \le PF \le 1.0 \text{ for a given } \mathbf{S_{Load}}$$

4. Q_C shall be limited to discrete values in increments of 0.25 MVAr

Part 3. Engineering Documentation Deliverables

1. Prepare a report that presents your calculations, analysis, and discussions of the data collected in Part 1.
2. For the Power Factor Correction Function
    a. Thoroughly document the code to describe how the function works. Include a function description at the beginning of the code and comments throughout.
    b. Write a user manual on how to use the function.
    c. Demonstrate the power factor correction function by producing a plot of Q_C as a function of P_L and Q_L given the ranges and constraints noted above.

The report shall be submitted via Canvas as a single pdf file.