Portland State University

Electrical & Computer Engineering

EE 347 Power Systems I

- Lab 1. Power Lab Fundamentals-

Introduction

This laboratory assignment introduces students to the power equipment and software that will be used in subsequent laboratory assignments. Students build a simple three-phase power circuit using the LabVolt EMS equipment, particularly the three-phase power supply, synchronous motor, dynamometer and complex loads. Students use the LVDAC-EMS software to measure voltage and current, which in turn are used to calculate power, etc.

Objectives

Through laboratory exploration, students learn how to:

- Build complex, three-phase AC circuits, including
    - a three-phase power supply
    - complex three-phase loads
    - a three-phase rotating machine
- Measure power (instantaneous, real and reactive) in complex AC circuits.
- Observe phase shift between voltage and current as a function of complex load.

Analyze and interpret data, and draw conclusions

Develop engineering documentation:

- Bills of material
- One-line diagrams

Part 1: Circuit Build and Data Gathering

1.1 Introduction to Lock-Out/Tag-Out

The GTA will guide students through the safety procedure known as lock-out/tag-out. It is imperative that everyone follow this procedure when operating electrical power equipment. The service voltages and the rotating equipment available in the lab can be harmful, so it is imperative that all students understand the energized state of systems when working on them. Lock-out/tag-out is a mechanism by which the energy state of a system is communicated to a group. Everyone is expected to follow lock-out/tag-out when working on energizable equipment in the power lab.

1.2 Introduction to the power equipment and software tools.

For this lab, students build two circuits: an electric power circuit with passive elements and an electromechanical system. These use a three-phase power supply, synchronous motor, constant-torque dynamometer, passive elements, and various metering.

Likely, students have not encountered circuits like these before, so it is imperative to carefully observe the procedures. In particular:

- The configuration of voltmeters and ammeters must be understood. Voltmeters are connected in a shunt configuration and ammeters in a series configuration. Doing the opposite will result in nonsensical readings in the former case and a blown fuse in the latter case.
- There is a specific procedure that must be followed when starting a synchronous motor. Failure to do so can cause pole-slipping, which can be damaging to the machine.
- Excitation of a synchronous machine rotor, via the 120 VDC power supply, is how reactive power is controlled.
- The dynamometer will need to be properly configured as a constant torque (CT) load. Torque is controlled via the LVDAC software.

Circuit 1 - Passive Power Circuit

Connect the 120/208 V power supply to wye-configured R, RL and RC loads. Record measurements of current (**I**), voltage (**V**), frequency (f), and real and reactive power (P, Q) as a function of load for the following loads:

$\mathbf{Z_R}$ = [300, 600, 1200] **Ω**
$\mathbf{Z_{RL}}$ = [300+j300, 300+j600, 300+j1200] **Ω**
$\mathbf{Z_{RC}}$ = [300-j300, 300-j600, 300-j1200] **Ω**

Circuit 2 - Electromechanical Power System

Connect an electromechanical system consisting of a 120/208 V power supply, a three-phase synchronous motor, and a dynamometer, which serves as a mechanical load. Record measurements of **I**, **V**, f, P and Q as a function of both torque (mechanical load) and rotor excitation for the following loads.

Procedure:

1. Follow the lock-out/tag-out start-up procedure
2. Energize the motor
3. Adjust the rotor excitation voltage, $V_{DC,Q=0}$, such that Q = 0 VAr.
    a. With $V_{DC,Q=0}$, sweep τ = [0.0: 1.0] Nm
    b. With $0.9V_{DC,Q=0}$, sweep τ = [0.0: 1.0] Nm
    c. With $1.1V_{DC,Q=0}$, sweep τ = [0.0, 1.0] Nm
4. De-energize the motor
5. Follow the lock-out/tag-out shut-down procedure

Part 2. Data Analysis and Interpretation, Drawing Conclusions

Calculate **V**, **I** and **S** for each Circuit 1 case.

For Circuit 1, analyze how **V**, **I**, f, P and Q vary with electrical loading. And for Circuit 2, analyze how **V**, **I**, f, P and Q vary with both mechanical loading and V_{DC} excitation. Compare calculations to observations and explain discrepancies. Discuss findings; does the analysis agree with intuition, and with theory as discussed in lecture?

Part 3. Engineering Documentation Deliverables

Prepare a brief report discussing the data analysis, interpretations, and conclusions. The report shall also include the following deliverables.

1. Bill of materials (BoM) that accounts for all equipment and supplies used during the demonstrations. An example BoM is posted within Canvas.
2. One-line diagram of the two demonstration circuits.
    a. The diagrams shall use the Power Lab AutoCAD Title Block, posted in Canvas.
    b. The diagrams shall start with the point of common connection (PCC), which is the 120/208 V receptacle to which the LabVolt power supply is connected. The cable connecting the PCC to the power supply is 10 feet of 5/C 12 AWG SOOW.
    c. Note locations for all metering.
    d. Label all components, including part numbers, in a comments section of the Title Block
    e. Note that the 3ϕ AC source of the LabVolt power supply actually is a 3ϕ variac.

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