ENERGY CONVERSION LABORATORY BASICS

The purpose of this experiment is to familiarize the student with the energy laboratory and its equipment and to develop good laboratory practices.

Laboratory Layout, Equipment, and Practices:

The machinery laboratory consists of the following:

1) Power pedestal
2) Laboratory bench
3) Load cart
4) Instruments and controls
5) Machines and transformers
6) A variac (a transformer with a variable turns ratio)
7) Interconnecting cables and wires

The Power pedestal can provide the following:

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Pilot Lamp Color</th>
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<tbody>
<tr>
<td>120V</td>
<td>- single phase - 60Hz (green)</td>
</tr>
<tr>
<td>208V/120V</td>
<td>- three phase - 60Hz (yellow)</td>
</tr>
<tr>
<td>120V</td>
<td>- three phase - 60Hz (blue)</td>
</tr>
<tr>
<td>240V</td>
<td>- three phase - 60Hz (white)</td>
</tr>
<tr>
<td>125V/250V</td>
<td>- dc (red)</td>
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Each of these sources is clearly marked on the pedestal and is provided with an ON/OFF switch and a pilot lamp. All required power for an experiment is supplied to the bench through this pedestal, through connecting multi-conductor power cables. In addition to 120v - single phase - 60Hz, any two of the remaining sources can be connected from the power pedestal to the bench through receptacles at the pedestal end of the bench labeled "CIRCUIT A" and "CIRCUIT B". Color-coded cables are used to avoid mistakes, with colored bands on the ends of the cables matching the colors of the pilot lamps. Again, to avoid any errors, each receptacle on the power pedestal matches only the corresponding color coded cable.

On the front of the bench are seven panel sections, as shown in figure 1. Details of the power input panel and the instrumentation connection panel are shown in figure 2.

All load connections to the power panel are made through the instrumentation panel, with the source connected to the left end of the instrumentation panel and the load connected to the right end of the instrumentation panel. All load connections are made with the heavy 12 AWG connecting conductors, with the smaller 18 AWG conductors used only in the voltage measuring circuits. The three-pole switch on the instrumentation panel is a fast acting circuit breaker and is used to protect and energize the circuit. In addition, the instrumentation panel provides for instrumenting a circuit after it has been constructed.

The load cart provides three separate sections each of resistance, capacitance and inductance. These may be either wye or delta connected for three-phase circuits or connected in series or parallel with shorting straps for single-phase or dc operation. The elements are rated for 120-volt operation. Each resistor element is controlled by switches, and the total load is controlled by adding elements in parallel. The normal power value of each element is indicated by the switch and is either 75 or 150 watts at 120 volts. Each capacitor section is also controlled by switches which adds capacitance in parallel. Each switch controls either 15 or 30 μF.

By closing the proper switches, power could be supplied to the load. In addition, by using the instrumentation panel, any instrumentation can be added to the circuit without making any changes in the existing wiring. It is good laboratory practice to connect the circuit sources and loads first and then add the instrumentation.
Any instruments requiring voltage (voltmeters or wattmeter voltage coils) can be connected across the desired lines through the small jacks on the instrument panel. Use a black and a red lead for each instrument to ease in checking and in observing polarities.

Instruments requiring current (ammeters or wattmeter current coils) should be supplied by opening the proper shorting switch and routing the current through the desired instrument(s). Once again, heavy leads must be used to carry current and it is good practice to position the instrument in the instrument panel as close to the shorting switch as possible.

If the instruments are equipped with range switches, it is good operating practice to position the switch at the highest range before energizing the circuit.

An important instrument that operates both as a digital multimeter and as a oscilloscope is the TeKmeter. Since this is an instrument that you will use often, but is rather user unfriendly, a photocopy of the TekMeter instruction manual is available from your Lab TA.

**ALWAYS HAVE THE INSTRUCTOR EXAMINE YOUR CIRCUIT BEFORE ENERGIZING.**

Energize the circuit by first closing all meter shorting switches, the power pedestals switch, and then the circuit energizing switch. Then open any meter shorting switches that connect to instruments requiring current.

Most ac current devices in the laboratory have a maximum current range of 5.0 amperes. To make current or power measurements on ac circuits where the current exceeds 5.0 amperes, a CURRENT TRANSFORMER (CT) is used. The current transformer has multiple range primaries and a 5.0 ampere secondary. For example, using the 10.0 ampere primary range means 10.0 amperes in the primary corresponds to 5.0 amperes in the secondary, or that all instrument readings connected to the secondary must be multiplied by 2. **UNDER NO CIRCUMSTANCES SHOULD THE SECONDARY OF THE CURRENT TRANSFORMER BE OPEN CIRCUITED WHEN THERE IS CURRENT IN THE PRIMARY COIL!** The shorting switch for the current transformer should be closed or the transformer should be connected to an ammeter.

De-energize a circuit starting with the power pedestals switch and remove all wiring.

**Procedure**

1. Parallel the three resistor sections of the load cart and connect them to the right hand side of the instrumentation connection panel according to the practices described in the lab procedures document. Be sure all the toggle switches on the load cart are in the off position. Use the red and the black terminals on the instrumentation connection panel.

2. Connect the dc ammeter and the dc voltmeter as shown in figure 3. Connect the instrumentation connection panel to CIRCUIT A.

3. Connect the 120V ac single phase source to the laboratory bench. This connection supplies the convenience receptacles on the bench. Turn the circuit breaker for this source ON. The green pilot light should be lit.

4. Connect the 125 V/250 V dc source from the power pedestal to CIRCUIT A of the laboratory bench, using the proper colored coded cable (red). Make sure that the pedestal breaker switch is in the OFF (down) position.

5. **Have your instructor examine your circuit.** To energize your circuit, first close all meter shorting switches (these short out the ammeters and protect them from transient currents that occur when you energize the circuit). Close the power pedestals switch and then close the circuit energizing switch. Now open any meter shorting switches.

6. Place the ammeter switch on the 3 A range and the voltmeter switch on the 250 V range. Adjust the load (with the three parallel resistor sections) so that the ammeter draws approximately 2.0 A. Record the voltage, current, and the amount of resistance (indicated in watts) shown by the resistor bank's toggle switches.

7. Deenergize the circuit starting from the power pedestal. Remove all wiring from the instrumentation panel. Disconnect the dc source from the bench.

8. Parallel the three resistor sections of the load cart with one of the fixed inductor banks (in the lower center of the load cart)
9. Connect the left side of the instrumentation connection panel to CIRCUIT A. Connect the 208 V/120V ac source from the power pedestal to CIRCUIT A on the bench.

10. Turn the TekMeter™ on and place it in the oscilloscope mode. Set channel one to read ac current and channel two to read ac volts. To set channel one to read current press: MENU -> INPUT -> CH1 PROBE -> 10mV=1A. (see TekMeter™ handout). Connect the current probe to channel 1. Set the range on the probe to 10mV=1A. Connect voltage leads to read the voltage across the load (be sure that the COM input is connected to the neutral (N)). Connect the current probe to read the current going into the load (pay attention to the CURRENT FLOW SYMBOL on the current probe).

11. Energize the circuit using the same procedure as in Part 5 above. Using the cursors measure the peak to peak values of the current and voltage. Using the cursors measure the frequency of the voltage. Measure the phase angle difference between the voltage and the current. Record all measurements and be sure to note weather the current is leading or lagging the voltage.

12. Add resistance to the circuit until the current is approximately twice the value as Part 11. Notice how the current waveform shifts in phase with relation to the voltage. Again, record the peak to peak values of the voltage and the current, and the phase angle between the voltage and the current. Record the indicated resistance.

13. Set the TekMeter™ to read true power (see the TekMeter™ handout). Record the RMS voltage and current, the power, and the power factor.

14. Deenergize the circuit starting with the power pedestal. Disconnect and remove all the wiring from the load cart and the instruments. Return all jumper wires and connecting cables to their original storage place. Place any faulty jumpers in the “Bad Lead” box at the front of the lab.

Report Questions

1. Sketch a circuit for the first lab set up. Show the voltage source, meters, and resistive load. Label the recorded values for voltage and current.

2. From your measurements in Part 6 calculate the power dissipated in the resistive load. Compare that to the power dissipation indicated by the toggle switches. Comment on the difference. (What voltage level is needed to match the indicated power dissipation?)

3. From the data recorded in Part 11 calculate the impedance (real and imaginary parts) of the load. Calculate the power factor of the load. Comment on any differences between the calculated power factor and the expected power factor.

4. Using the data recorded in Part 12 and assuming that the voltage and current are single frequency sinusoids, calculate the RMS value of the voltage and current. Compare this to the recorded values form Part 13. comment on any differences.

5. Using the data recorded in Part 12, calculate the power and the power factor. Compare this to the data recorded in Part 13. Comment on any differences.

6. Using the impedance calculated in Question 4 above and the recorded value of resistance used in Part 12, calculate the impedance used for Part 12. Compare this to the value found using the recorded voltage and current from Part 12. Comment on any differences.

7. In your opinion, what are the most important safety precautions to be taken and why?
FIG. #1 — FRONT VIEW OF BENCH

FIG. #2 — POWER AND INSTRUMENT DETAILS
FIG 3 --- D.C. CIRCUIT DIAGRAM