

ECE-311 (ECE, NDSU)  
Lab 6 – Experiment  
**Power 2: power-factor correction**

**1. Objective**

The objective of this experiment is to study the concept of power factor. Calculation and correction of the power factor of an electrical load are investigated.

**2. Introduction**

In ac circuits, power factor (pf) affects the price at which the power company can deliver power to your house (or factory or farm). Large industrial loads or plants (usually large motors) cause the pf to be lower than the ideal value of 1. If the load has a low pf, lines running to the plant will be forced to carry a higher current  $I_{rms}$ . Since line losses are proportional to  $(I_{rms})^2$ , the power company will be forced to generate more total power to furnish the same power to the plant. The power company will charge more for a load with a low pf or the plant must purchase and install large capacitors to raise the pf.

rms voltages and currents are used when discussing ac power so that the effectiveness of each source in delivering power to a resistive load can be compared. The effective value of dc is the dc value. Sinusoidal voltages/currents are converted to rms by dividing by  $\sqrt{2}$ . While sinusoidal waveforms are the most common type of ac (all house wiring), other ac waveforms are also used, such as half or full-wave rectified sinusoidal, square wave, triangular, or ramp. Each can be converted to rms by multiplying by a (different) constant.

At this time, you should refresh your memory on the concepts of complex power and power-factor correction. Please revisit class notes and read Chapter 11 from textbook.

**3. Preparation**

- (1) Consider the circuit of Figure 1.
  - (a) Calculate the impedance  $Z_L$  of the “load”.
  - (b) Given  $V_{G(M)}$  (maximum source sine generator voltage) = 5V, calculate the phasor current  $I$ ,  $V_{R(M)}$  (maximum voltage across the 100  $\Omega$  resistor),  $V_{L(M)}$  (maximum load voltage), and pf (load power factor).
- (2) Assume you used a multimeter (which reads rms voltage) to obtain the rms voltages for  $V_G$ ,  $V_R$ , and  $V_L$ . Convert the calculated (maximum) values from part 1 to rms values and use a phasor diagram to *graphically* determine the pf.
- (3) Calculate the capacitance which, when placed in parallel with the load, will raise the pf to 1.

- (4) Use LTSpice to determine the pf of the (original) load. Determine the phase difference between the load voltage and current. Then, include the capacitor (part 3) and determine the new pf.

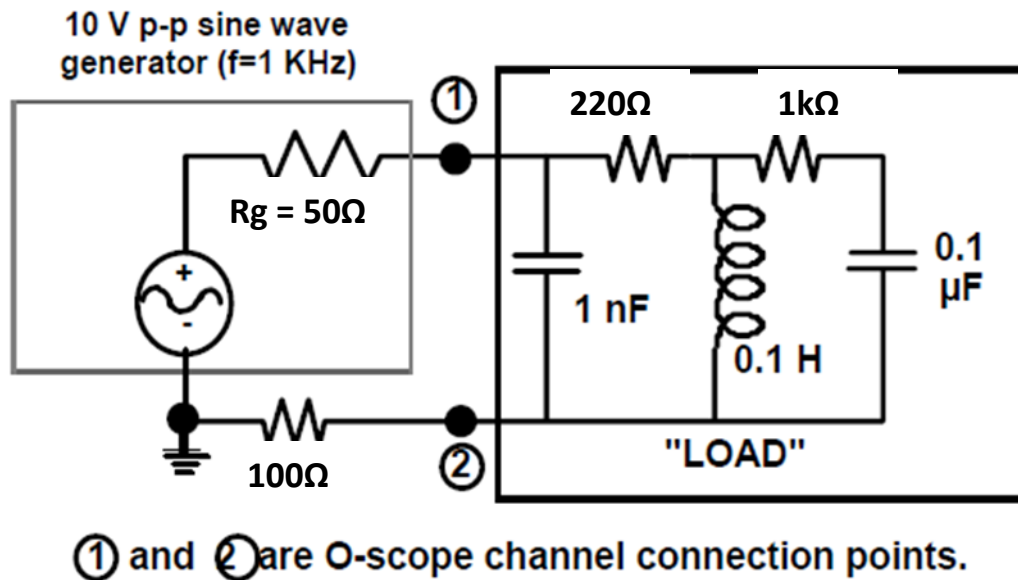


Figure 1: Power factor test circuit

#### 4. Experiment

- (1) Use the inductance/capacitance meter to measure the exact component values for the inductor and capacitors used in this experiment. Use a multimeter to measure the exact values for the resistors used.
  
- (2) Use the oscilloscope to measure the phase angle between the load voltage and load current (measured through the 100Ω resistor). Connect the O-scope and circuit as in Figure 1.
 

*Note: since the signal generator and O-scope are both internally grounded to the power line, measuring the phase angle between the load voltage and the current is not straightforward. One method is to (similar to one of the techniques you learned in previous labs!):*

  - i) Connect channels 1 and 2 as shown. Set ch1 to be the trigger, and set the same vertical amplification for each channel. (Now “ch1-ch2” is the load voltage and “ch2/100Ω” is the load current).
  - ii) Observe ch2 and adjust so a positive slope zero crossing aligns with a graticule (line on the O-scope face).
  - iii) Switch to ADD mode (with ch2 inverted) to get the load voltage signal.
  - iv) Measure phase shift by measuring the time shift between positive zero crossings of “ch1-ch2” and “ch2” (the screen graticule set in part ii).
  - v) Make sure the waveforms are centered about the zero-volt axis (they tend to shift when going to/from the “ch1-ch2” mode).

Use the (rms) multimeter to measure the voltages across the load, generator, and the 100 $\Omega$  “current measuring” resistor.

Use the measured phase angle and the rms voltage/current from the meter to calculate the power factor pf.

(3)

(a) Calculate the capacitance needed to raise the pf to 1.

(b) Connect the calculated capacitance (from a), re-adjust the signal generator to 10V p-p, and again measure the phase angle between the load voltage and current.

(c) Again use the rms multimeter to measure the voltages across the load, generator, and the 100 $\Omega$  resistor (as in part 2).

Repeat the power factor calculation of step 2.

## 5. Results

(1) Compare the pf determined 1) analytically (part 1 in section 3 of this lab), 2) graphically (part 2 in section 3 of this lab), 3) with LTSpice (part 4 of section 3 of this lab), 4) with the O-scope in the lab. Discuss any variations in results.

(2) What would you do to improve this experiment?