EE 137A Homework #2

due Thursday, Sep 13, 2018

1. Phasors

Let $v = 141.4\cos(\omega t - 60°)$ and $i = 11.31\cos(\omega t - 30°)$.

(a) What are the maximum value and rms value for each?

(b) Draw the two waveforms in the time domain.

(c) State a phasor expression for each in both polar and rectangular form.

(d) Restate the phasors in polar form after changing your coordinate system to use voltage as the reference.

(e) Is this circuit inductive or capacitive?

(f) Suppose the above quantities are measured in a circuit that contains a resistance and a reactive element in series. What are the values of R and X?

(g) What are the values of R and X if they are in parallel? Why does it make sense for these values to be greater or less than in (f)?

2. Power Factor

A single-phase a.c. voltage of 240V is applied to a series circuit whose impedance is $10\angle 60°\ \Omega$.

(a) Find R, X, |S|, P, Q, and the power factor of the circuit.

(b) If a capacitor is connected in parallel with this circuit and supplies 1250 VAR, find the P and Q supplied by the 240-V source, and the resultant power factor.

3. Reactive Compensation

A circuit supplied by a 120-V a.c. source has a resistance of 8 Ω in series with an inductive reactance of $j6\ \Omega$.

(a) What is the impedance in polar form? In your own words, explain why it makes intuitive sense for the impedance not to be $14\ \Omega$.

(b) What is the inductance L in henrys if the a.c. frequency is 60 Hz, and what is it if the frequency is 50 Hz? (Don't forget 2π.) For which of the remaining parts of this problem do we need to know what the frequency actually is? (When you get there, take it to be 60 Hz.)

(c) What is the current phasor?

(d) What are **S**, P and Q?

(e) Suppose you wish to improve the power factor of the entire circuit to 0.95 lagging, by placing a capacitor in parallel with the R-X_L combination. What is the value of the capacitive reactance X_C required?

(f) What is the capacitance in farads?

(g) How many joules of energy are exchanged every half-cycle between the inductor and the capacitor, and how many joules between the inductor and the voltage source?

continued

4. The "Power Save"

(a) Visit http://www.solardirect.com/energy/power-saving/power-save/index.html and watch the demonstration video. What does the Power-Save unit do?

(b) Suppose I run an air conditioner compressor pump rated 20 Amps (at 120V) at a power factor of 0.60. What is its electric energy consumption during an hour of continuous operation?

(c) Suppose I install the Power-Save unit in my home, where the air conditioner is the only load. What will be the effect? Explain using a power triangle diagram.

(d) Suppose that the air conditioner compressor operates for five hour every day, and ignore all other loads. Assume that as a residential customer, my utility meter does not measure VARs, and that my electric rate is $0.20/kWh. To a rough approximation, what savings might I expect on my electric bill due to the Power-Save device? You will have to make some important assumptions here; state them. (Hints: How far away from the meter is the air conditioner? What's the resistance per unit length of standard 14-gauge copper wire? Where should I put the Power-Save unit?)

(e) The website suggests savings of up to 25% on your monthly electric bills. Does this claim seem realistic? Is there anything factually wrong in the video presentation? Are any of the statements misleading? Explain. (Hint: It's a scam, but subtle.)

(f) Can you describe a scenario where a residential customer who is not billed for reactive power would obtain significant savings from the Power-Save device?

5. The Up Goer Five

Randall Munroe, author of the *xkcd* comic strip and *The Thing Explainer*, proposed a funny way of explaining scientific concepts using only the "ten hundred words people use most often" (original at http://xkcd.com/1133/). Using the online text editor at http://splasho.com/upgoer5/, try your hand at explaining a basic concept of electrical engineering in Up Goer Five style, in about a paragraph. You may choose to define a term such as Electric Circuit, Voltage, Inductance, Capacitance, Alternating Current, Phasor, Reactive Power... or another relevant concept. For inspiration, read "How Our Power Lines Will Handle Everyone's Power From the Sun" by Michael Cohen, posted in the Readings folder.

Hard Review Questions, not for submission

What's so special about the number e = 2.71828…? Could you use a different base for writing phasors? What happens when you plot 2^(jx) or 10^(jx) in the complex plane?

Consider the complex and phasor quantities **S**, **Z**, **I** and **V**. None of them have an explicit time dependence. In each case, what happened to the time variable?

Is **V** = **I Z** still a true statement if the frequency changes? Explain.

Is **S** = **I***V** still a true statement if the frequency changes? Explain.

Recommended Practice, not for submission

In Glover, Overbye & Sarma (GOS) 6th edition, do the following for extra practice:

Multiple choice questions for sections 2.1, 2.2, 2.3

Problems 2.1, 2.2, 2.5, 2.7, 2.8, 2.9