ELEC 225 Circuit Theory I Fall 2013

Homework Assignment #7 – due in BRKI 368 at 4 pm Friday, Nov. 8, 2013

***Instructions, notes, and hints*:**

You may make reasonable assumptions and approximations in order to compensate for missing information, if any. Provide the details of all solutions, including important intermediate steps. You will not receive credit if you do not show your work.

All Problems: Unless otherwise specified, complex impedances should be expressed in rectangular form, and voltage and current phasors should be expressed in polar form.

***Assignment*:**

Probs. 7.20, 7.23ade, 7.31, and 7.33 in the textbook plus the following additional problem:

1. The diagram below models the ×10 probes used with the oscilloscopes in the lab. The resistance R_{in} and capacitance C_{in} represent the equivalent input resistance and capacitance, respectively, of one of the oscilloscope's channels. (C_{in} includes the capacitance of the coaxial test lead; 86 pF of cable capacitance is added to the 14-pF input capacitance of the oscilloscope alone.) The probe is designed so that the voltage $\mathbf{V}_{in}$ that appears at the oscilloscope's input will be 1/10 of the voltage being measured ($\mathbf{V}_{test}$). (That is why you have to press the "Probe" button on the oscilloscope and select "10:1" to get the correct voltage readings.) Because of the presence of C_{in}, a simple resistive voltage divider will not suffice. Capacitor C_p must be added in parallel with R_p to compensate. If the values of R_p and C_p are chosen correctly, the probe will produce the desired 1/10 voltage magnitude reduction but no phase shift at all frequencies of operation. For the values of R_{in} and C_{in} given, find the required values of R_p and C_p so that $\mathbf{V}_{in} = 0.1\mathbf{V}_{test}$ (i.e., the magnitude of phasor $\mathbf{V}_{test}$ is reduced by 1/10 and the phase is unchanged) regardless of frequency. *Time-saver*: The equivalent impedance of the parallel combination of a resistor R and a capacitor C can be expressed as:

$$R \left\| \frac{1}{j\omega C} \right. = \frac{1}{\dfrac{1}{R} + \dfrac{1}{1/j\omega C}} = \frac{1}{\dfrac{1}{R} + j\omega C} = \frac{R}{1 + j\omega RC}.$$

Hint: Express the R_p-C_p combination as equivalent impedance Z_p and the R_{in}-C_{in} combination as equivalent impedance Z_{in}, and use the voltage divider formula to relate $\mathbf{V}_{in}$ to $\mathbf{V}_{test}$.