Circuits

Exam 3

Spring 2020

1.	/30
2.	/20
3.	/30
4.	/20
Total	/100

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Notes:

1) If you are stuck on one part of the problem, choose 'reasonable' values on the following parts to receive partial credit
2) You don't need to simplify all your numerical calculations. For example, you can leave square root terms in radical form

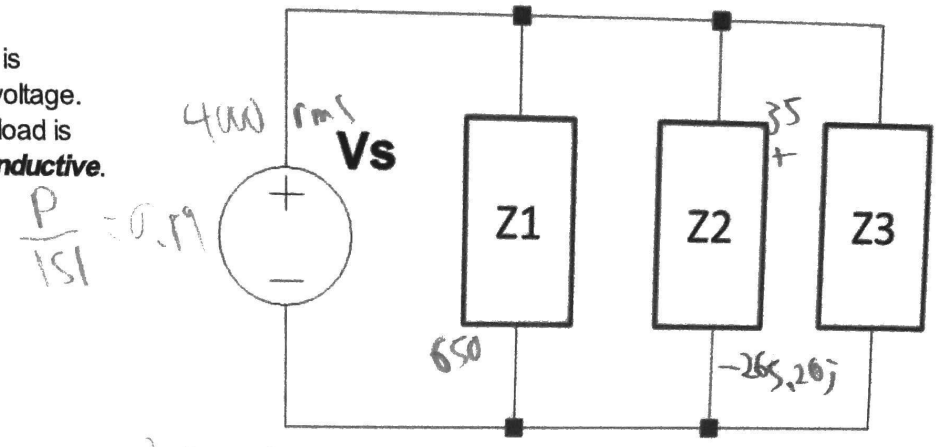
1) Power Circuits (30 points)

In this circuit, the total source power, S, is 25,000 VA with a 60 Hz, 4,000 VRMS voltage. The power factor for the entire parallel load is 0.89and the total load ***appears to be inductive***. The loads are described below:

Z1: Purely resistive heating element, 650 Ω

Z2: Capacitive element with small real loss, R=35 Ω, C= 10 μF

Z3: Unknown load



$\frac{P}{151} = 0.89$

$35 - 265.26j = Z_2$

$\frac{4000^2}{35+265.26j}$ $\cdot\cos(-82.48) + \frac{4000^2(j)}{35+265.26j}\cdot\sin(-82.48)$

1.1: Determine the values in the table below. Please show all work for full credit! Every box is worth 2 points. Partial credit is not given for wrong answers in boxes.

$-57752.36 - 15514.2i$

	P[W]	Q [VAR]	|S| [VA]	power factor
Load 1	24615	0	24615	1
Load 2	-57752.36	-15514.17	59799.87	-.965
Load 3	55387.36	-4115.17	55540.02	.8557
Source	22250	11309	25000	0.89

$S = \frac{4000}{35-265.26j} \cdot 4000 = 7822.55 + 5926j$

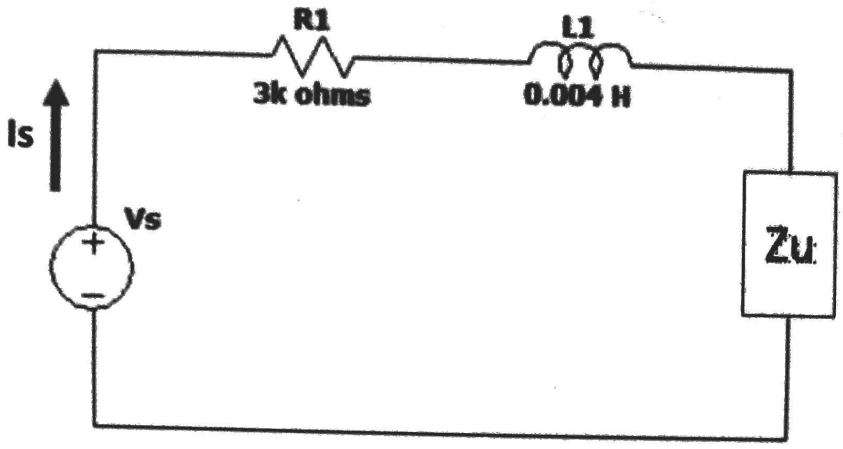
$PF = \frac{P_1+P_2+P_3}{25000}$

$\sqrt{P^2+X^2} = 25000$

$X = 11309$

More space on next page!

Problem 2) Phasor Analysis (20 pts)



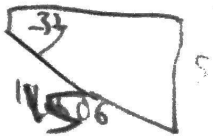
In the above circuit, Zu is unknown. The voltage source is $V_s(t) = 15\cdot\cos\left(2.5\cdot10^6 t - 32°\right)$

and the current through the source is $I_s(t) = 0.0009\cos\left(2.5\cdot10^6 t + 40°\right)$

2.1: Determine the complex impedance, Zu, that satifies the relationship between Vs(t) and Is(t).

$$\frac{V_s(t)}{3k+(62831.85)+X} = 0.009\cos(2.5\cdot10^6 t+40°)$$

$$\frac{15\angle -32°}{3k+62831.85j+Y} = 0.0009\angle 40°$$

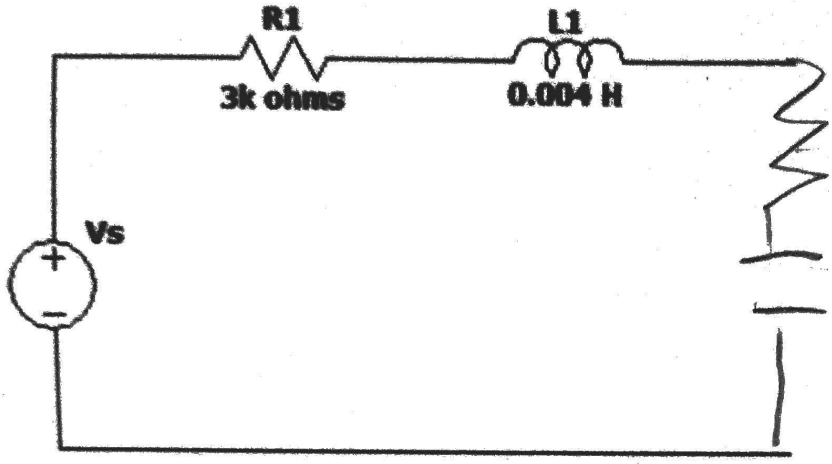


$$\frac{12.72+(-7.45j)}{3k+X+-10000j} = 6.89\times10^{-4}+5.785\times10^{-4}j$$

$$X = 2145.9 - 25859.07$$

Zu	2145.9 −25859.1j

2.2: Using a combination of resistors, capacitors, and/or inductances (you only need two components), complete the circuit from the answer in part 2.1. (Carried over mistakes will NOT be counted against you. Make sure process is correct!)



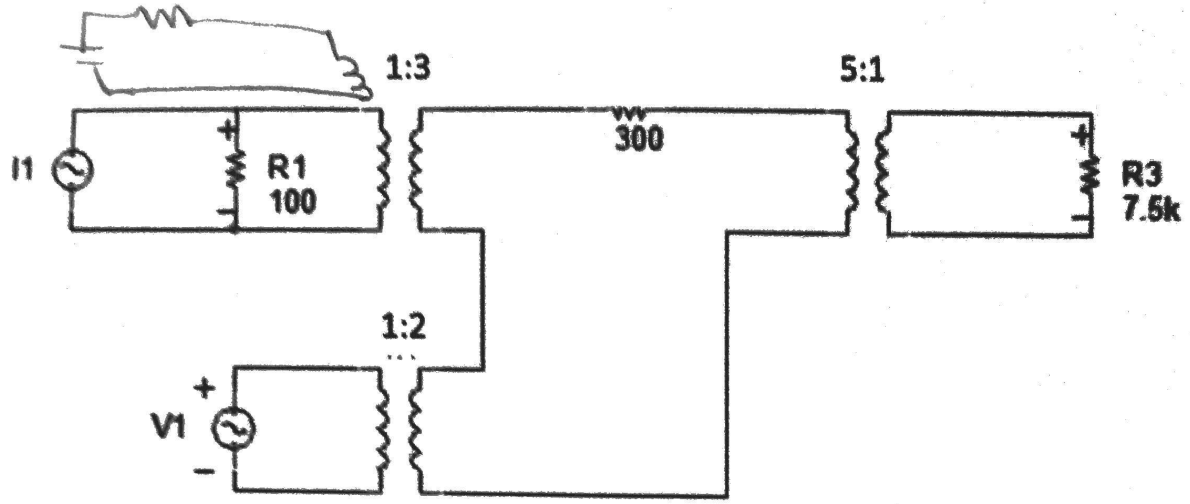
2145.9 ohm

1.54×10^{-11} F

$\therefore -25859.1\,j = \frac{1}{j \cdot 1.25 \cdot 10^{6} \cdot C}$

$C = 1.54 \times 10^{-11}$

Problem 3) Transformers (30 pts)



For the above circuit, the sources are

$$V1(t) = 15 \cdot \cos(377t) \text{ Volts}$$

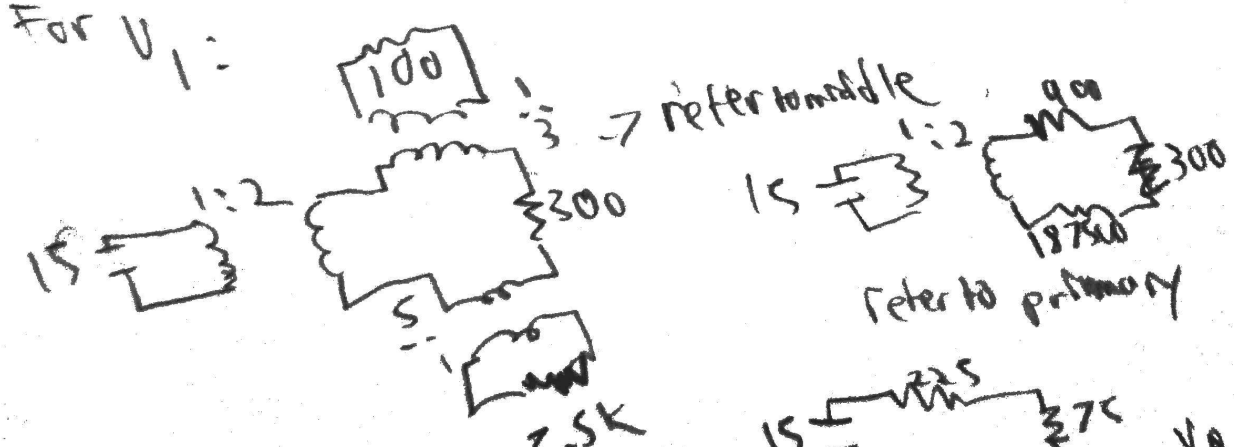
$$I_1(t) = 0.035 \cos(377t) \text{ Amps}$$

3.1: Find VR3 (include schematics for circuits to help explain your process).

Super position; $V_1 = 15$

$I_1 = 0.035$ Source transform = 3.5 V

For V_1:



$$V_{R3} = V_1 \frac{15(468.75)}{225+75+468.75} = 14.9 \text{ V}$$

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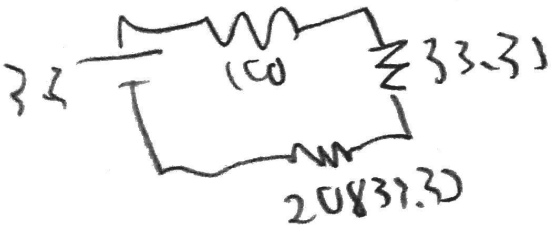
VR3	$18.37 \angle 0^\circ$

For $I_1 \Rightarrow V_{1I_1}$ =

refer to middle

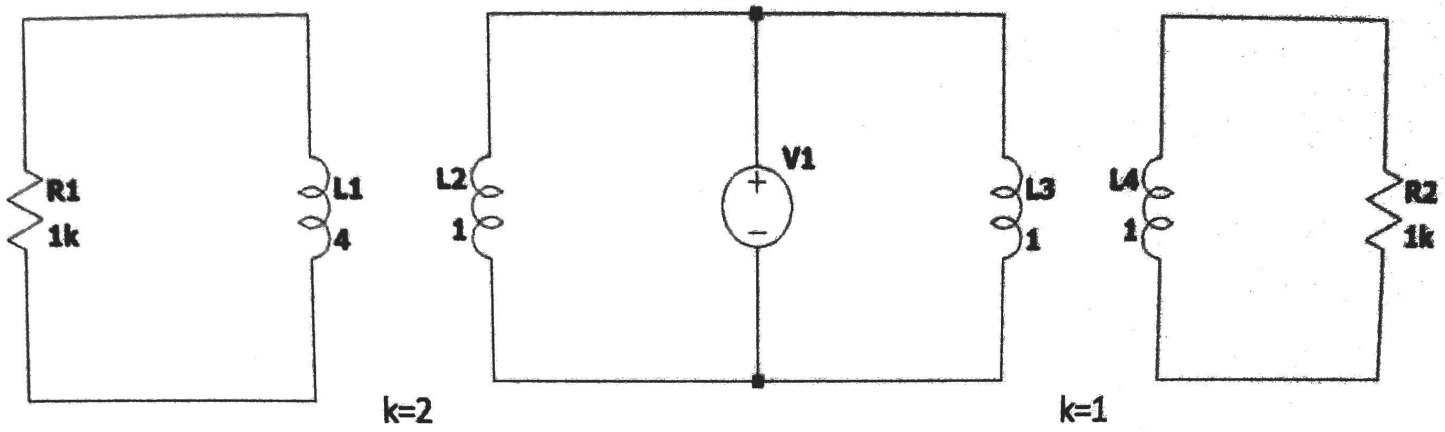
refer to primary



$$V_{R_3} = \frac{3.5(20833.33)}{100 + 22.22 + 20833.33}$$

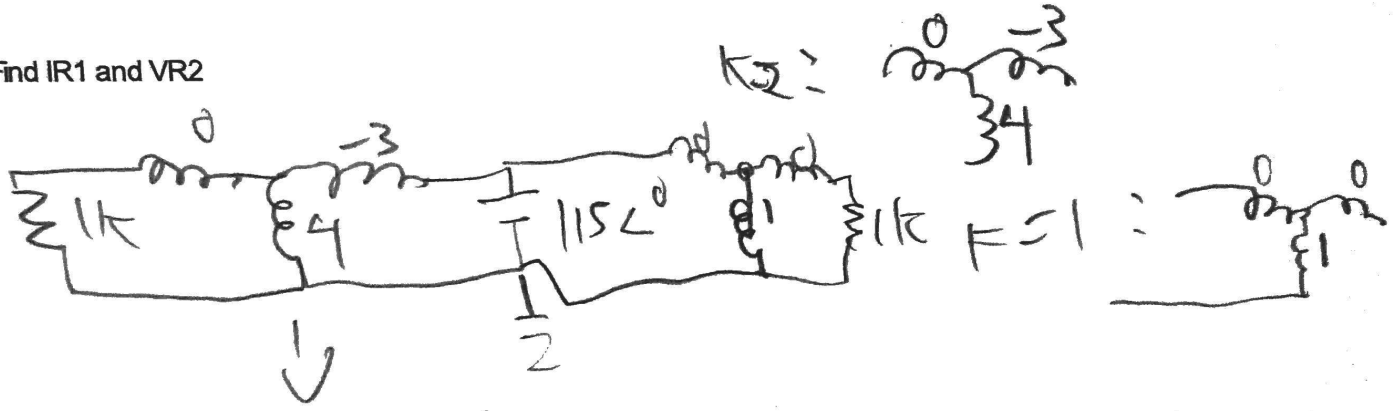
$$= 3.47\ V$$

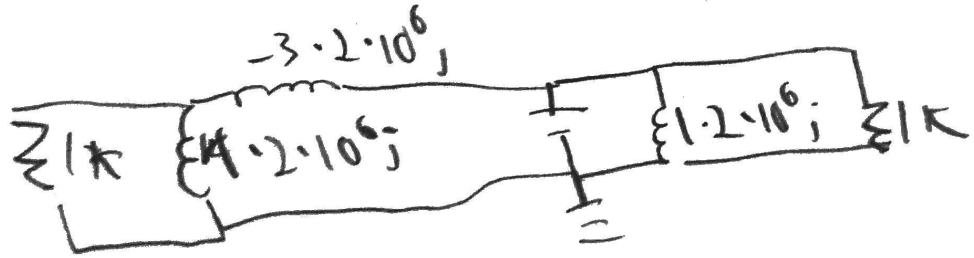
Thus $V_{R_3} = 14.9 + 3.47 = 18.37$



$$V_1 = 115\cos\left(2\cdot 10^6 t\right)$$

3.2: Find IR1 and VR2





$VR_2 = 115\angle 0$

$$115 = \square - 6\times10^6 j \quad \square 1k \quad \square 8\cdot10^6 j \qquad \frac{115\left(\frac{1}{1000}+\frac{1}{8\cdot10^6 j}\right)^{-1}}{-6\times10^6 j + \left(\frac{1}{1000}+\frac{1}{8\cdot10^6 j}\right)^{-1}} = 7.986\times10^{-7} + .02j$$

$$\frac{7.986\times10^{-7} + .02j}{1000}$$

$$= IR_1 = 7.986\times10^{-10} + .00001916j$$

polar

$$= 1.916\times10^{-5}\angle 90^\circ$$

IR1	$1.916 \times 10^{-5} \angle 90^0$
VR2	$115 \angle 0^0$

4) FACTS! Write True or False next to each statement (20 pts)

1. A power factor of 0 is impossible to achieve in a non-ideal world.
True
2. Root Mean Square (RMS) is the same as standard deviation if the mean is zero.
True
3. A phasor is a vector in the complex plane with a magnitude that changes with time.
False
4. Eddie and Tessie had a long distance power battle. Eddie won.
False
5. Reactive power values for source and load of a circuit should balance to 0.
True
6. When using impedance in polar form to calcualte complex power and $VRMS^2$, the complex conjugate of Z should be used.
True
7. Reactive Power is "stored" by passing energy from capacitor to inductor.
True
8. A transformer can operate with a step function.
False
9. The angle of impedance is ΦI - ΦV because of ohm's law
False
10. Real power can be negative
False

Explain your answer to 1.
Every bit of wire is an inductor so in AC systems where PF matters it can never be truly zero. Also every 2 wires is a cap and thus adding another reactive element.

Explain your answer to 3.
The phasor vector is not time dependent. It is frequency and magnitude dependent.

Explain your answer to 7.
Caps have -Q and Inductor +Q. They pass energy into each other as dynamic components.