

# Circuits

## Exam 3

Spring 2020

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

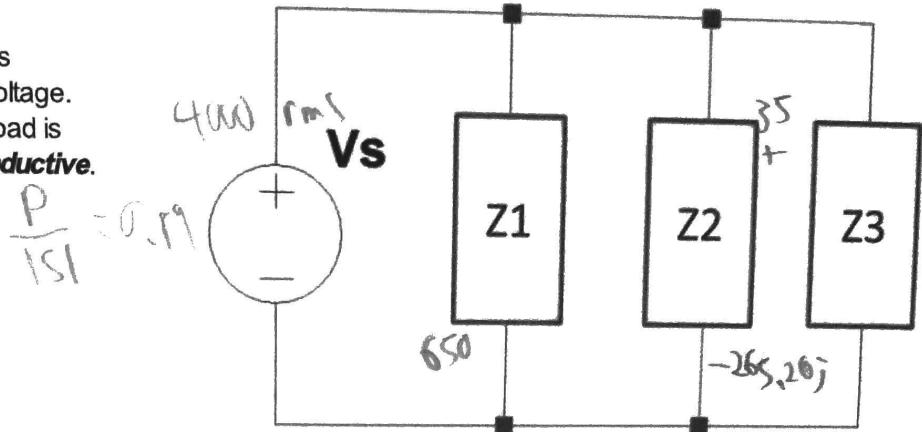
Name Saif Ahmed

### 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 0.89 and 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

$$35 - 265.26j = 22$$

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

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	-0.965
Load 3	55387.36	-4115.17	55540.02	0.8557
Source	22250	11309	25000	0.89

$$\underline{S} = \frac{4000}{35 - 265.26j} \cdot 4000 = 7822.55 + 59286j$$

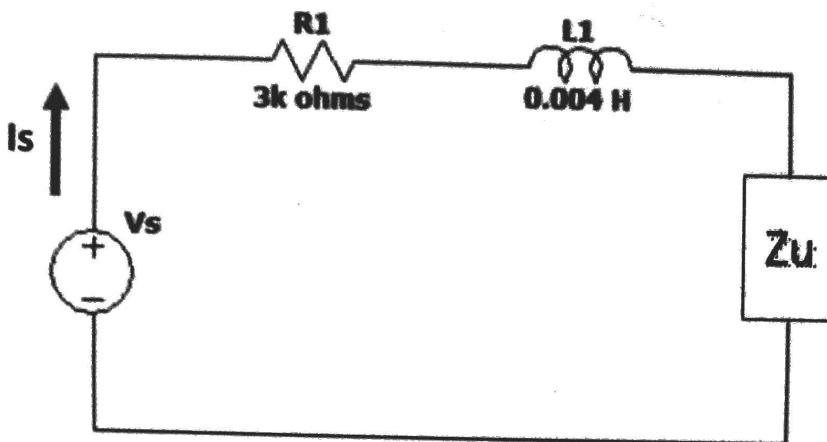
$$P_Q = \frac{P_1 + P_2 + P_3}{25000}$$

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

$$Q = 11309$$

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Problem 2) Phasor Analysis (20 pts)

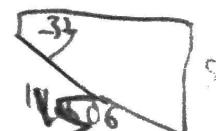


In the above circuit,  $Z_u$  is unknown. The voltage source is  $V_s(t) = 15 \cdot \cos(2.5 \cdot 10^6 t - 32^\circ)$   
 and the current through the source is  $I_s(t) = 0.0009 \cos(2.5 \cdot 10^6 t + 40^\circ)$

2.1: Determine the complex impedance,  $Z_u$ , that satisfies the relationship between  $V_s(t)$  and  $I_s(t)$ .

$$\frac{V_s(t)}{3k + (62831.85)j + X} = 0.0009 \cos(2.5 \cdot 10^6 t + 70^\circ)$$

$$\frac{15}{3k + (62831.85)j + X} = 0.0009 \angle 40^\circ$$

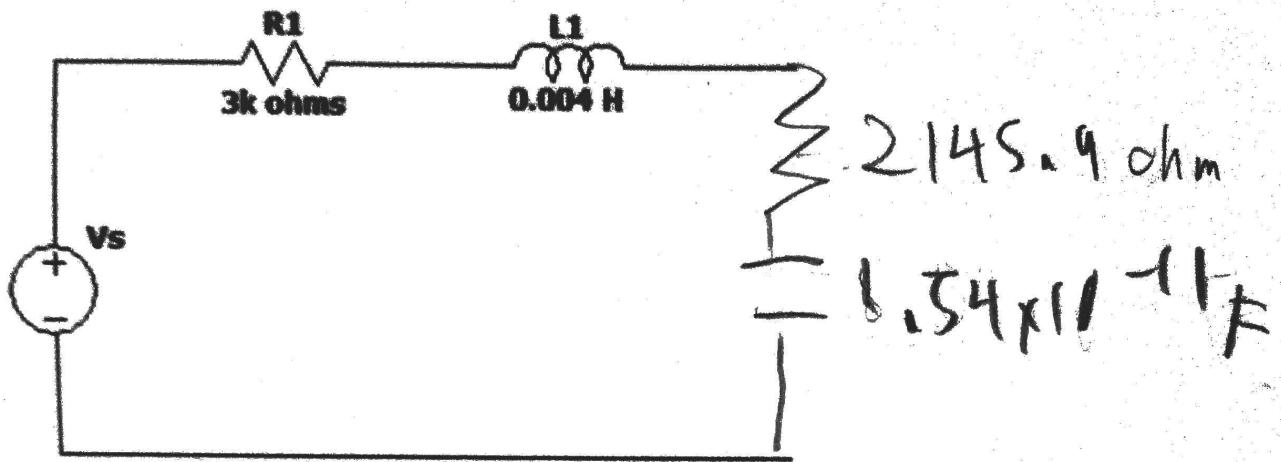


$$\frac{12.72 + (-7.45j)}{3k + X + j10000} = 6.89 \times 10^{-4} + 5.785 \times 10^{-4}j$$

$$X = 2145.9 - 25859.07$$

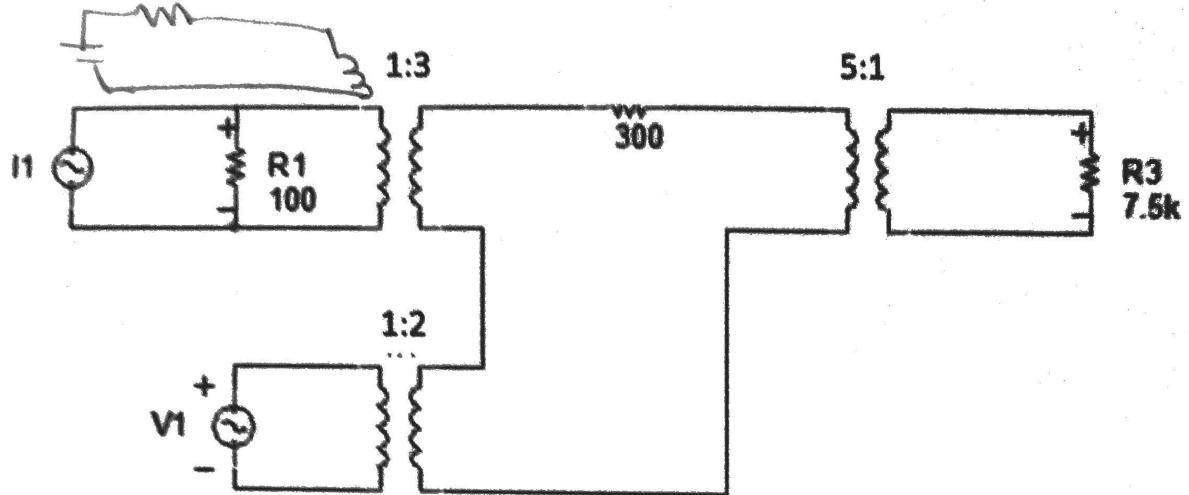
$Z_u$	$2145.9 - 25859.07j$
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2.2: Using a combination of resistors, capacitors, and/or inductances (you only need two components), complete the circuit from the answer in part 2.1. (Carried over mistakes will NOT be counted against you. Make sure process is correct!)



$$-25859.1 \angle -90^\circ = \frac{1}{j \cdot 1.25 \cdot 10^6 \cdot C}$$
$$(= 1.54 \times 10^{-1})$$

Problem 3) Transformers (30 pts)



For the above circuit, the sources are

$$V_1(t) = 15 \cdot \cos(377t) \text{ Volts}$$

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

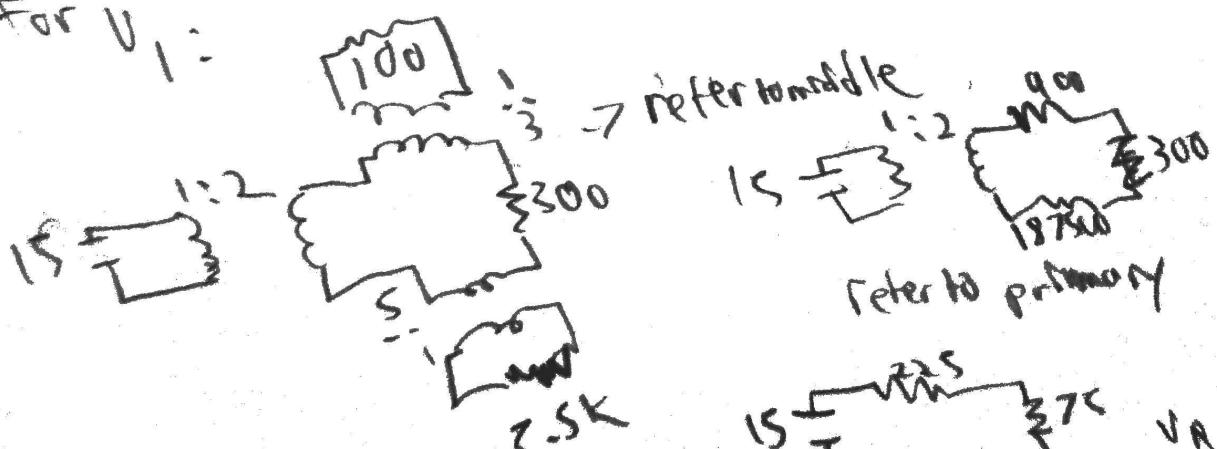
3.1: Find VR3 (include schematics for circuits to help explain your process).

Super position:

$$V_1 = 15$$

$$I_1 = 0.035 \text{ Service transform} = 3.5 \text{ V}$$

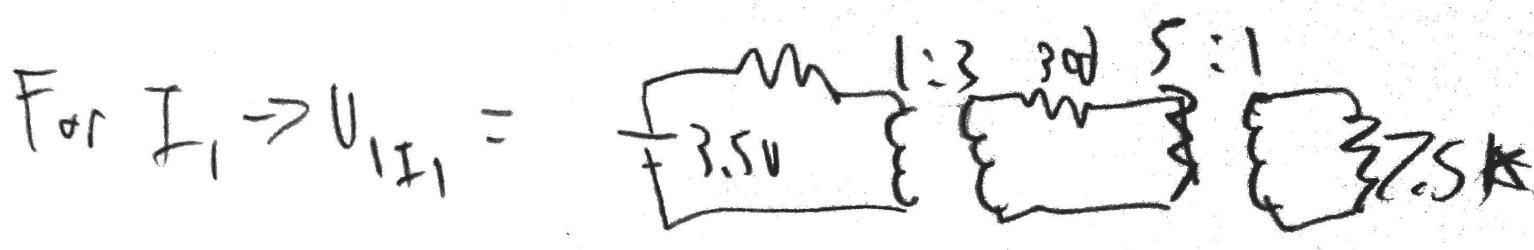
For  $V_1$ :



(continued on  
other page) →

$$\begin{aligned} VR_3 &= \frac{15(4687)}{225 + 75 + 4687} \\ &= 14.9 \text{ V} \end{aligned}$$

VR3	$18.37 \angle 0^\circ$
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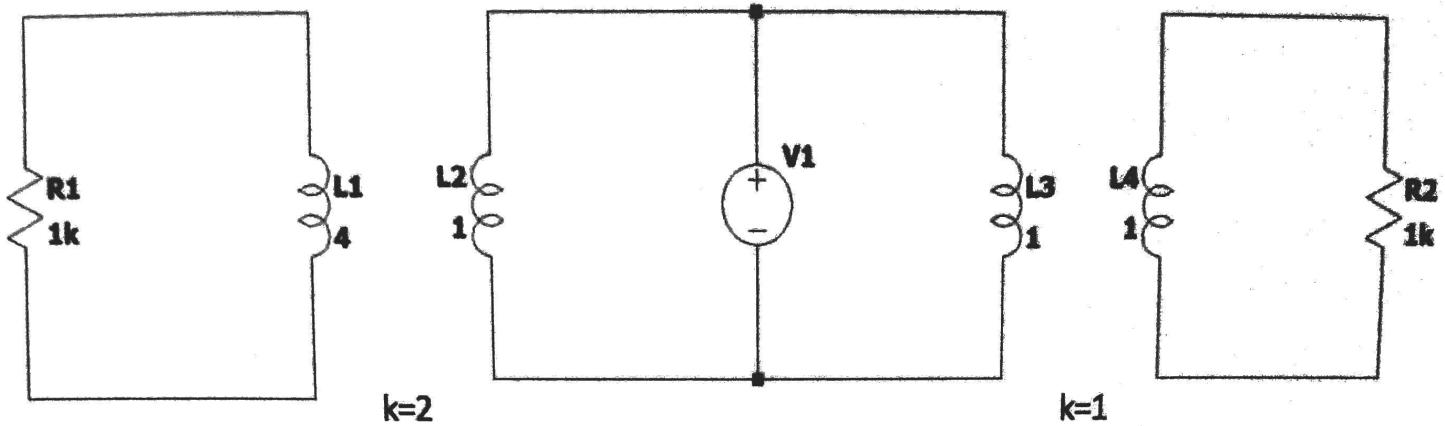
refer to middle



refer to primary

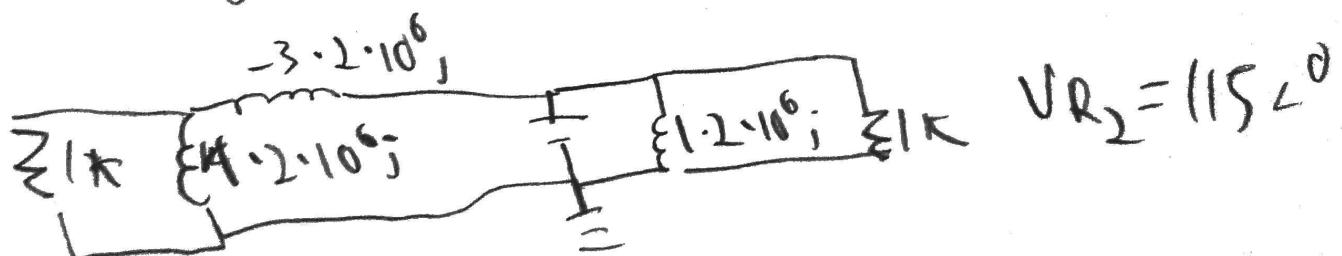
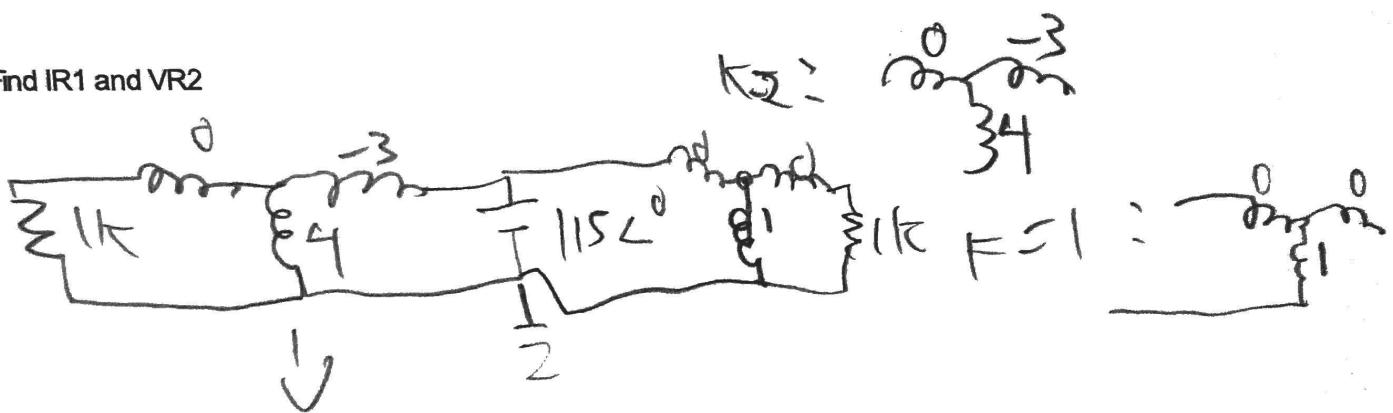
$$3.5 \frac{1}{100} \left( \frac{20833.33}{100 + 22.22 + 20833.33} \right) = 3.47 V$$

Thw.  $V_{R3} = 14.4 + 3.47 = 11.37$



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

3.2: Find  $IR_1$  and  $VR_2$



$$115 = \frac{115 \left( \frac{1}{1000} + \frac{1}{8 \cdot 10^6 j} \right)^{-1}}{-6 \cdot 10^6 j + \left( \frac{1}{1000} + \frac{1}{8 \cdot 10^6 j} \right)^{-1}} = \frac{7.986 \times 10^{-7} + 0.2 j}{1000}$$

$$= IR_1 = 7.486 \times 10^{-10}$$

pdar

$$= 1.916 \times 10^{-5} \angle 90^\circ - 0.0001416 j$$

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

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 calculate 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  $\Phi_I - \Phi_V$  because of ohm's law

False

10. Real power can be negative

False

Explain your answer to 1.

Every conductor always has a non-zero resistance due to attraction from protons thus it will always have some real power.

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 Inductors  $+Q$ . They pass energy into each other as dynamic components.