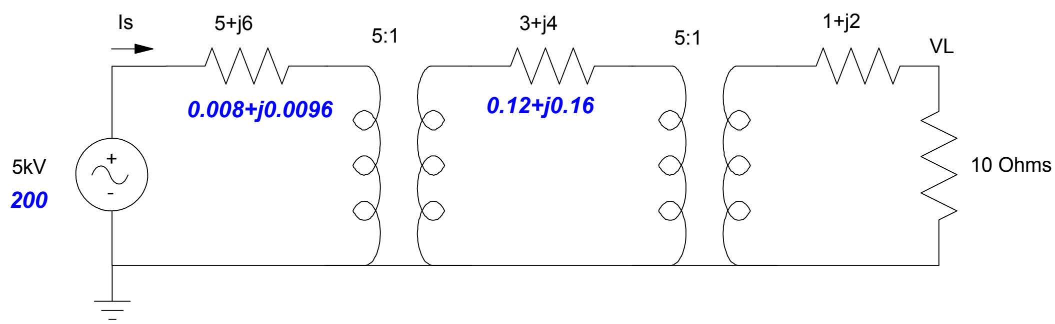
ECE 331: Test #2 Name ________________

Transformers - March 5, 2014

1) Ideal Transformer: Assuming ideal transformers, determine the voltage across the 10 Ohm resistor (V_L) and the source current (I_S). Assume all voltages and currents are rms.



V_L (Volts)	I_S (Amps)
$176.4\angle -11^0$	$0.705\angle -11^0$

First, remove the transformers by bringing all impedances and voltages to the right (left also works).

This is shown in blue

Find the current

$$I_L = \frac{200V}{(0.008+j0.0096)+(0.12+j0.16)+(1+j2)+10}$$

$$I_L = 17.64\angle -11^0$$

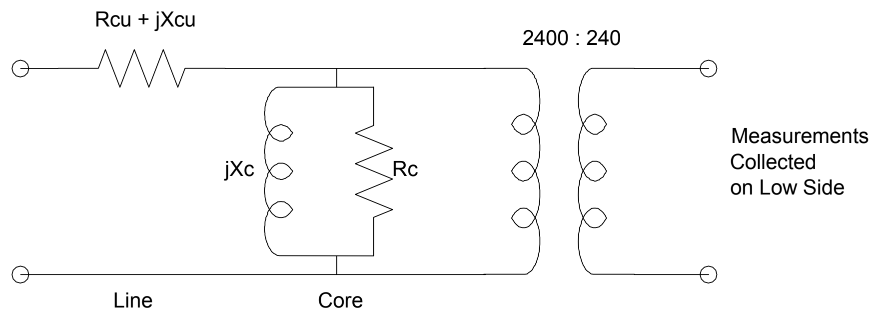
VL is then

$$V_L = 10\Omega \cdot I_L = 176.4\angle -11^0$$

To find Is, go through the transformers. These raise the voltage by 25x. To keep power constant, current drops by 25x

$$I_s = \frac{1}{25} \cdot 17.64\angle -11^0$$

2) Transformer Testing: The following no-load and short-circuit test data was taken from a transformer on the low-side. Determine the core and line model for the transformer



No-Load Test (Data collected on low (240V) side)	Short Circuit Test (Data collected on low (240V) side)
V = 240V rms I = 0.2 A rms P = 4 Watts	V = 24V rms I = 12A rms P = 250 Watts

Rcu	jXcu	Rcore	jXcore
1.7631	**j0.9929**	**14400**	**j1204**

Core:

$$|Z_c| = \frac{240V}{0.2A} = 1200$$

$$\angle Z = \arccos\left(\frac{4W}{240V \cdot 0.2A}\right) = 85.2^0$$

$$Z_c = 1200\angle 85.2^0$$

Convert to parallel form

$$\frac{1}{Z_c} = \frac{1}{14400} + \frac{1}{j1204}$$

Line (copper)

$$|Z_{Cu}| = \frac{24V}{12A} = 2$$

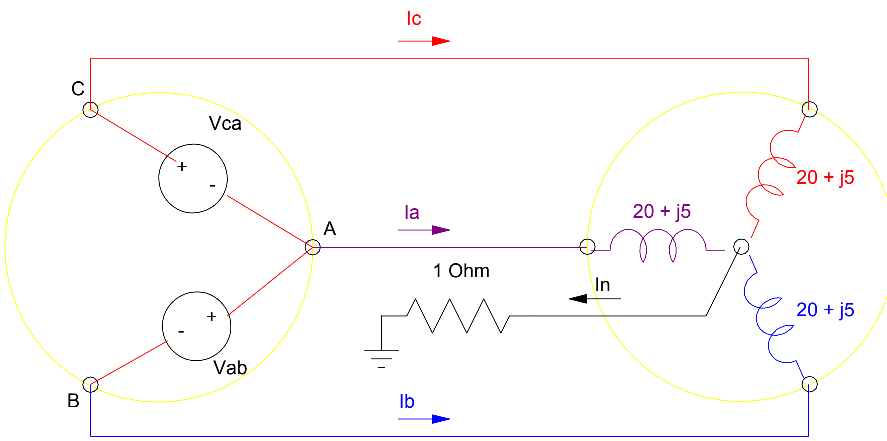
$$\angle Z_{Cu} = \arccos\left(\frac{250W}{24V \cdot 12A}\right) = 29.76^0$$

$$Z_{Cu} = 2\angle 29.76^0$$

$$Z_{Cu} = 1.7631 + j0.9929$$

3) 3-Phase and Delta-Y Connections. A 3-phase transformer in V configuration is connected to a balanced load in Y configuration. Determine the line current, Ia, and the neutral current, In

Ia (Phase A line current)	In (ground current)
$67.21\angle -44^0$	**0 (balanced load)**



$V_{ab} = 2400\angle 0^0$ Vrms $\qquad V_{ca} = 2400\angle -240^0$ Vrms

It's a balanced load, so you know that the voltage and current at the neutral is zero.

This lets you do per-phase analysis. The line-to-neutral voltage is $\frac{1}{\sqrt{3}}$ times the line-to-line voltage.

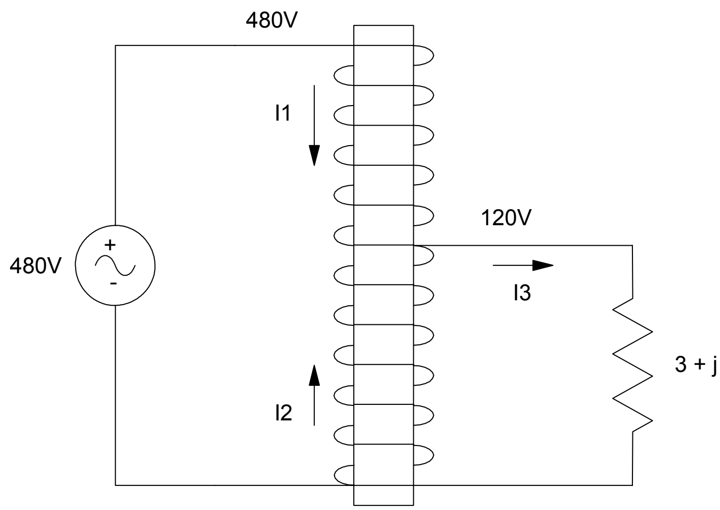
$$V_{AN} = \frac{2400}{\sqrt{3}}\angle -30^0$$

So

$$I_A = \frac{V_{AN}}{20+j5}$$

4) Auto-Transformer: An Auto-Transformer connects a 480V source to a 120V load. Determine the currents I1, I2, and I3. Assume all units are rms.

I1	I2	I3
$9.48\angle -18^0$	$28.46\angle -18^0$	$37.94\angle -18^0$



I3 is

$$I_3 = \frac{120V}{3+j} = 37.94\angle -18^0$$

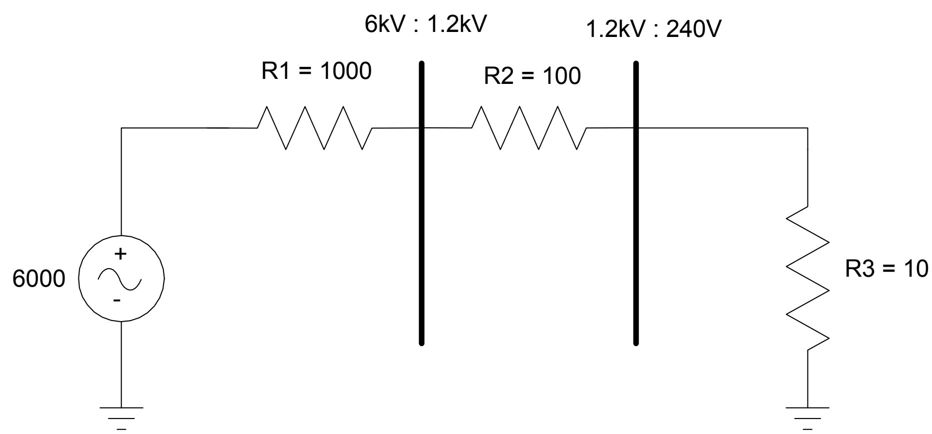
The current I1 changes by the turn ratio

$$I_1 = \left(\frac{120V}{480V}\right) I_3 = 9.48\angle -18^0$$

I2 comes from the current summing to zero

$$I_2 + I_1 = I_3$$

5) Per-unit analysis: A power grid consists of two transformers and a 10 Ohm load.



5a) Give the per-unit values for Io and Zo in at each voltage using Po = 100kVA:

Vo = 6000 V rms	Vo = 1200 V rms	Vo = 240 V rms
Po = 100 kVA	Po = 100 kVA	Po = 100 kVA
Io = 16.67 A	Io = 83.33 A	Io = 416.67 A
Zo = 360 Ohms	Zo = 14.40 Ohms	Zo = 0.576 Ohms

5b) Determine the per-unit values of R1, R2, and R3

R1	R2	R3
2.77	**6.944**	**17.36**