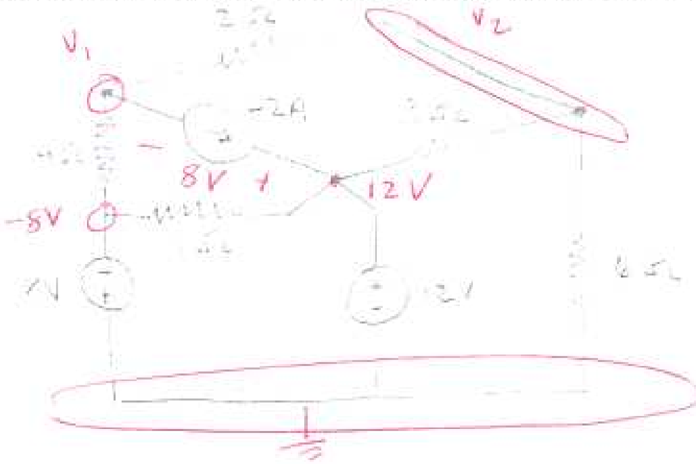
EE331 – Final Review

1. Determine the power delivered by the current source in the circuit depicted below:

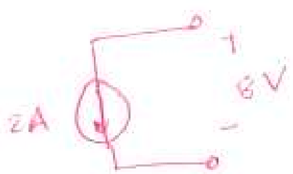


$$\frac{v_1+8}{4} + \frac{v_1-v_2}{2} = 2 \Rightarrow v_1+8+2v_1-2v_2 = 8$$
$$3v_1 - 2v_2 = 0$$

$$\frac{v_2-v_1}{2} + \frac{v_2-12}{3} + \frac{v_2}{6} = 0 \Rightarrow 3v_2-3v_1+2v_2-24+v_2=0$$
$$-3v_1+6v_2 = 24$$

$v_2 = 6$

$v_1 = 4$

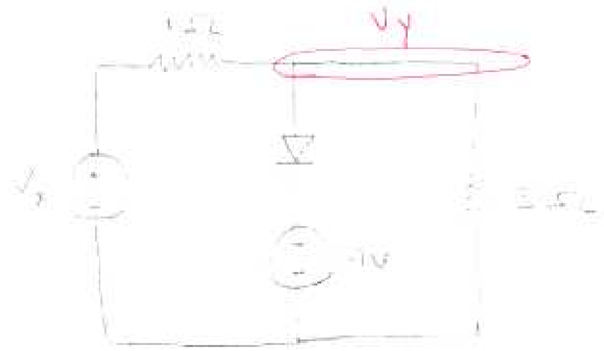


$P = 16\ W$

16 W is being dissipated by the current sour[ce]

−16W delivered.

2. Determine the range of V_x in the circuit below that will cause the ideal diode to be on (conducting).



in order for the diode to conduct $V_y - 9 > 0$

$V_y > 9$

when is $V_y = 9$ V.

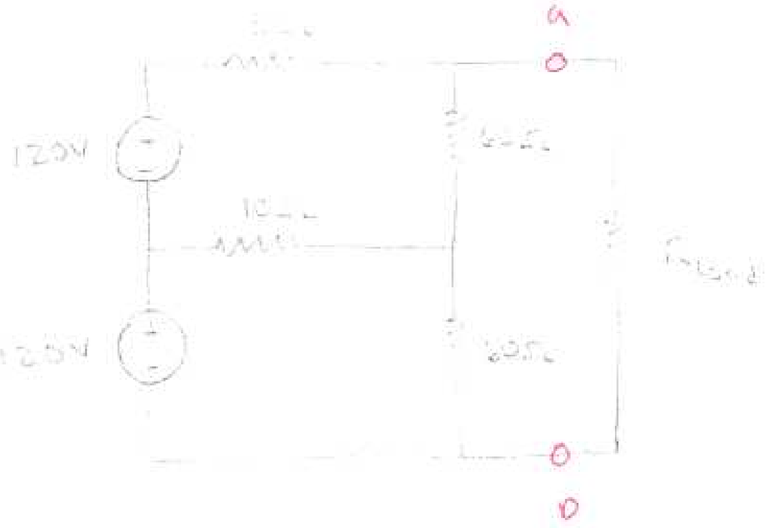
if diode is off ($V_y \leq 9$ v) then

$$V_y = \frac{3}{1+3} V_x$$

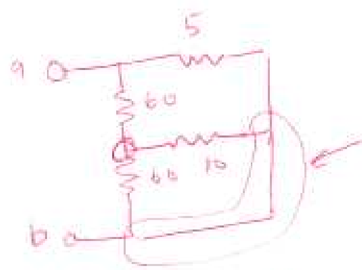
$$9 = \frac{3}{4} V_x \Rightarrow V_x = 12\text{ V}$$

diode conducts when $V_x > 12$ V

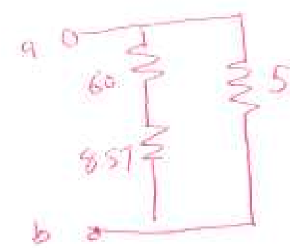
3. Calculate and draw the Thevenin equivalent circuit seen by R_{Load} in the following circuit.



① calculate R_{th}



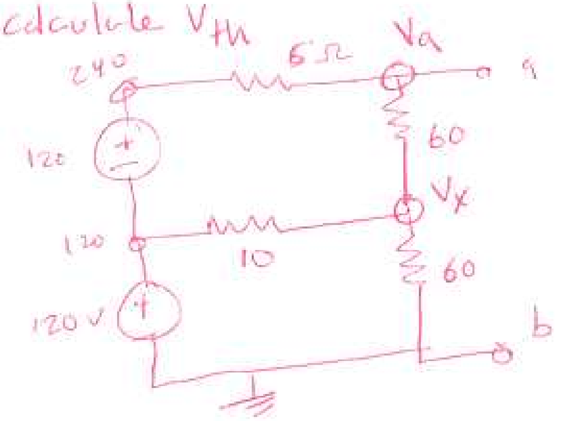
$60 \| 10 = \frac{600}{70} = 8.57\,\Omega$



$R_{th} = 5 \,\|\, (60 + 8.57)$

$= 4.66\,\Omega$

② calculate V_{th}



use nodal.

① $\frac{V_a - 240}{5} + \frac{V_a - V_x}{60} = 0$

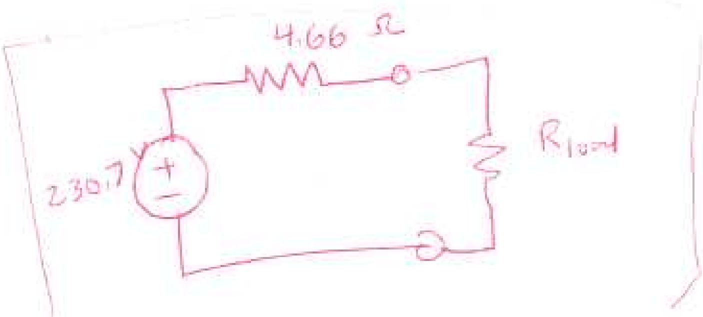
② $\frac{V_x - V_a}{60} + \frac{V_x - 120}{10} + \frac{V_x}{60} = 0$

① $13 V_a - V_x = 2880$

② $-V_a + 8V_x = 720$

$V_a = 230.7\ V \Rightarrow V_{ab} = 230.7\ V$

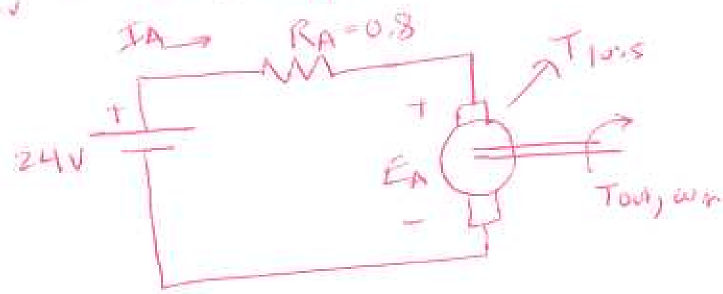
$V_x = 118.8\ V$



4. When an armature voltage of $24V_{DC}$ is applied to a loaded permanent magnet DC motor with $R_a = 0.8\Omega$ and $K_v = 0.1592V{\cdot}s$, it spins at 1200rpm.

a. Determine the loss torque, T_{Loss}, if this motor is 70% efficient at this speed.

$\omega_m = \frac{1200\ rpm}{min} \cdot \frac{1\ min}{60\ sec} \cdot \frac{2\pi\ rad}{1\ rev} = 125.7\ rad/s$



$E_A = K_V \omega_m$

$= (0.1592)(125.7)$

$= 20\ V$

$I_A = \frac{V_T - E_A}{R_A} = \frac{24-20}{0.8\ \Omega} = 5A$

$P_{in} = V_T I_A = (24V)5\ A = 120W$

$P_{loss,total} = 0.3 \cdot 120W = 36\ W$

$\uparrow (1-\eta)$

$P_{RA} = I^2 R_A = 25(.8) = 20W$

$\Rightarrow$ power loss due to T_{loss} is

$36 - 20W = 16W$

$P_{loss} = T_{loss} \cdot \omega_m$

$16\ W = T_{loss} \cdot 125.7$

$T_{loss} = 0.127\ N{\cdot}m$

b. If an external resistance of 0.8Ω were placed in series with the armature (R_a) with the same T_{load} and T_{loss}, what would be the new speed and efficiency?

$T_{load} = \frac{0.7(120)}{\omega_m} = 0.668$ N·m

$T_{dev} = T_{load} + T_{loss} = 0.668 + 0.127$
$= 0.796$ N·m

$T_{dev} = K_V I_A \Rightarrow I_A = \frac{T_{dev}}{K_V} = \frac{0.796}{0.1592} = 5$ A (still)

$E_A = V_T - I_A(0.8 + 0.8)$
$= 24 - 5(1.6)$
$= 16$ V

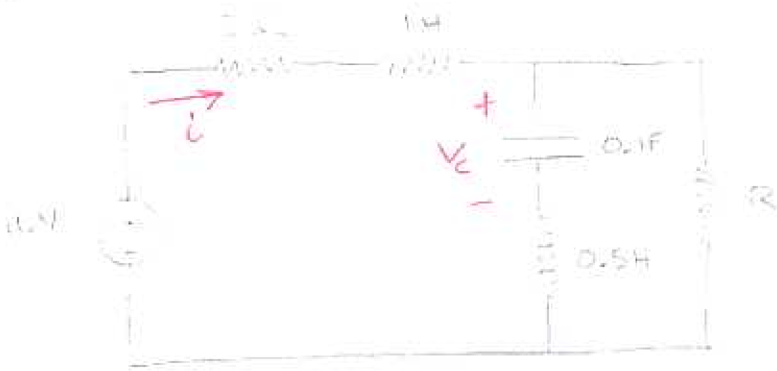
$\Rightarrow E_a = K_V \omega$
$\omega = \frac{E_a}{K_V} = \frac{16}{0.1592} = 100.5$ rad/sec
($N = 960$ rpm)

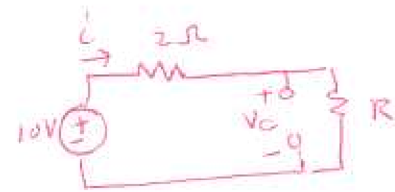
$P_{out} = T_{load}\,\omega$
$= (0.668)(100.5) = 67.2$ W

$P_{in} = (24\text{ V})(5) = 120$ W

$\eta = \frac{P_{out}}{P_{in}} = \frac{67.2}{120} = 0.5598$
$= 56.0\%$

5. Find the value of R that will result in a total steady-state stored energy of 10J in the following DC circuit.





- In steady-state, capacitor becomes open circuit, therefor the 0.5H inductor will store no energy.

- Total energy = $\frac{1}{2} L i^2 + \frac{1}{2} C V_c^2$

- note that in steady-state, $V_c = iR$

thus $$10 = \frac{1}{2}(1) i^2 + \frac{1}{2} C (iR)^2$$

$$10 = \frac{i^2}{2} + \frac{i^2 R^2}{20}$$

$$200 = (10 + R^2)\, i^2$$

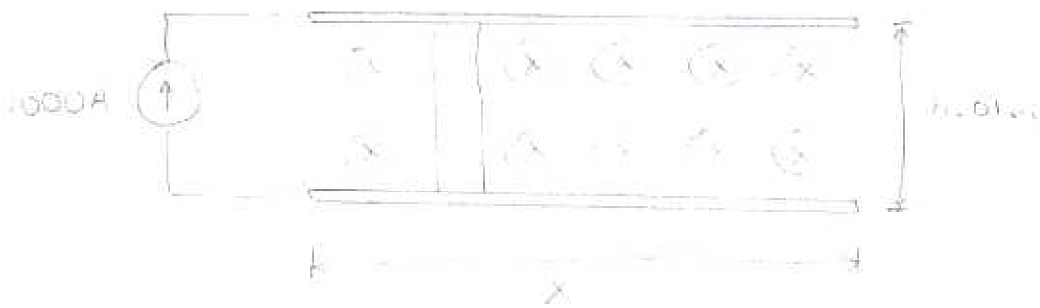
- also, from steady state $$i = \frac{10\,V}{(2+R)}$$

- Thus (2 eq, 2 unknow)

$$200 = (10 + R^2)\left(\frac{10}{2+R}\right)^2$$

$R = 0.243\ \Omega$

6. Consider the following linear DC motor where B = 1.5T and the mass of the projectile is 1kg.



a. Determine the barrel length x necessary to result in a launch energy of 60J.

$w = \frac{1}{2} m v^2$

$60 = \frac{1}{2}(1) v^2 \Rightarrow v = \sqrt{120} = 10.95$ m/s

$F = B l i = (1.5)(0.01)(1000) = 15$ N

$a = \frac{F}{m} = \frac{15\text{ N}}{1\text{ kg}} = 15$ m/s²

$W = F \cdot x$

$60 = 15 \cdot x$

$x = 4$ m

b. Find the time to launch.

$x = \frac{1}{2} a t^2$

$4 = \frac{1}{2}(15) t^2$

$t = \sqrt{\frac{8}{15}} = 0.730$ sec

or

$v = at$

$10.95 = 15\, t$

$t = 0.730$

e. How much current would be required if you wished to shorten the launch time to 0.5s (keeping x the same).

if $x = 4\,m$ and $t = 1/2$ sec

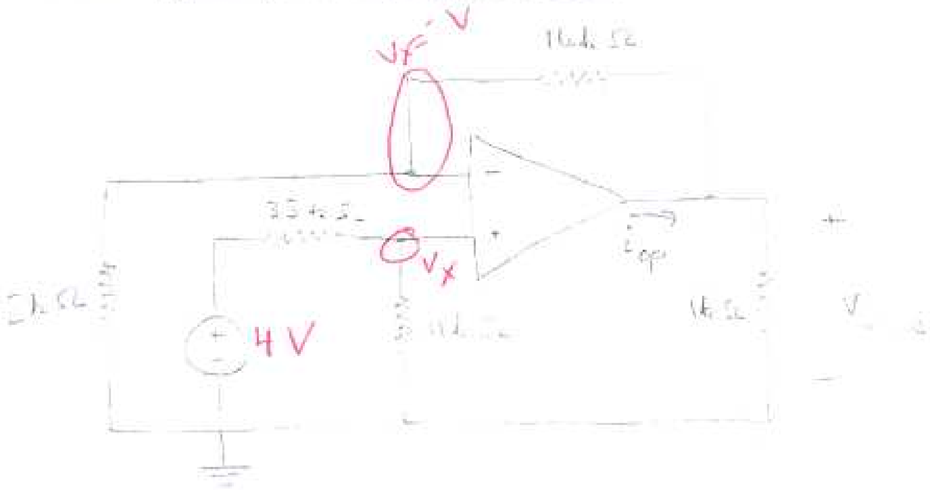
$$x = \frac{1}{2} a t^2$$

$$4 = \frac{1}{2} a \left(\frac{1}{2}\right)^2 \Rightarrow a = 32\ m/s^2$$

$F = B\ell i \qquad F = ma$

$$\Rightarrow i = \frac{F}{B\ell} = \frac{ma}{B\ell} = \frac{(1)(32)}{(1.5)(0.01)} = \boxed{2133\ A}$$

7. Find V_{load} and i_{op} in the op-amp circuit below.



① $V_x = \frac{11k}{11k+33k} \cdot 4 = 1V$

② KCL @ inverting input

$$\frac{1}{2k} + \frac{1-V_{load}}{16k} = 0$$

$$8 + 1 - V_{load} = 0 \Rightarrow \boxed{V_{load} = 9\ V}$$

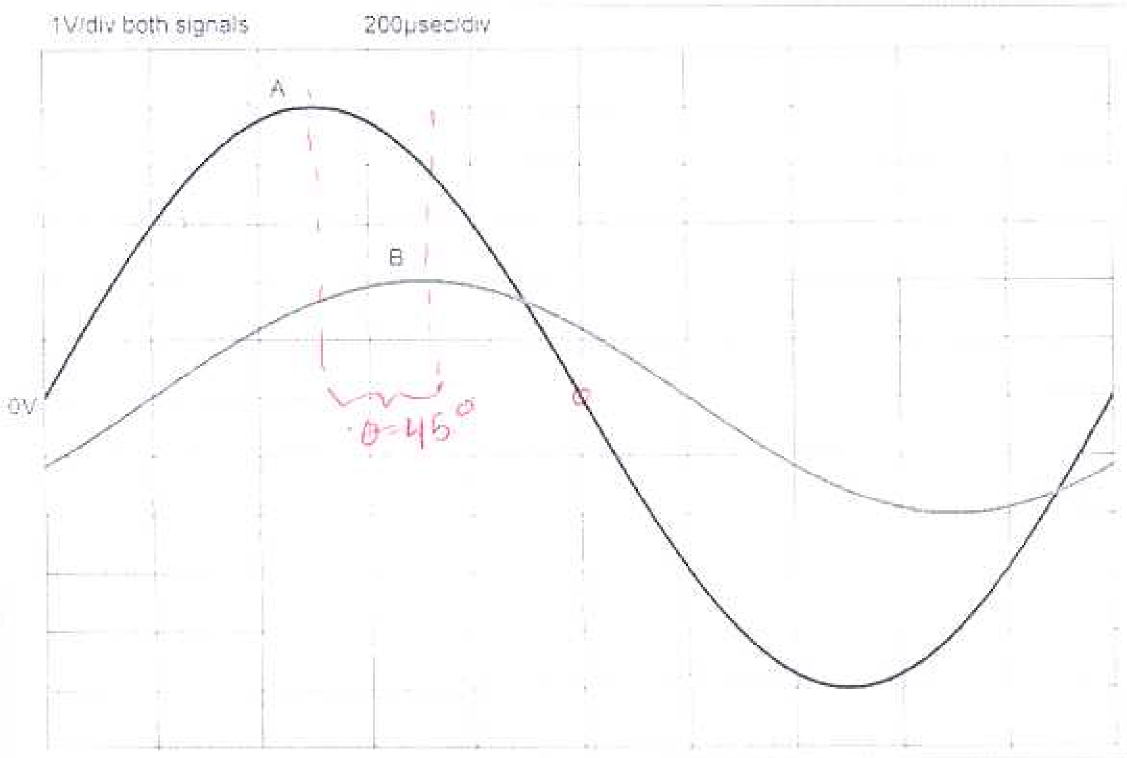
③ KCL @ V_{load}

$$\frac{V_{load}-1}{16k} + \frac{V_{load}}{1k} = i_{op}$$

$$\frac{8}{16k} + \frac{9}{1k} = i_{op}$$

$$\boxed{i_{op} = 9.5\,mA}$$

8. Given the following sinusoidal waveforms:



a. Find the frequency of the two signals (Hz)

$T = (10\ div)(200\mu s/div) = 0.002 \qquad f = \frac{1}{T} = 500\ Hz$

b. What is the rms value of signal A?

$V_m = (5\ div)(1\ V/div) = 5V \qquad V_{rms} = \frac{5}{\sqrt{2}} = 3.54\ V_{rms}$

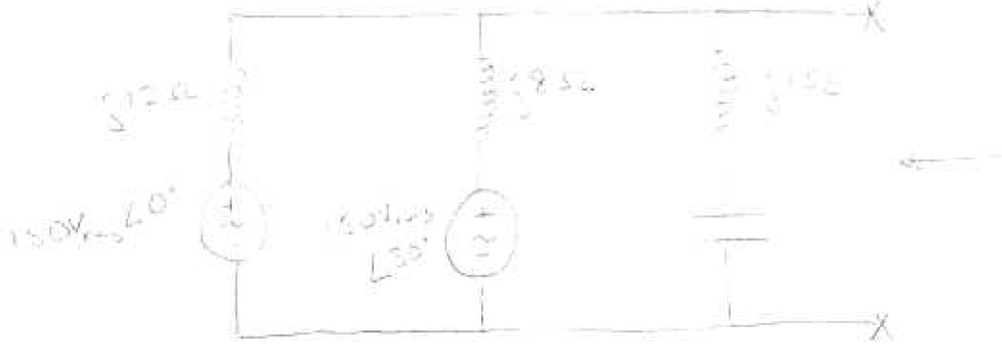
c. What is the average value of signal B?

0 V

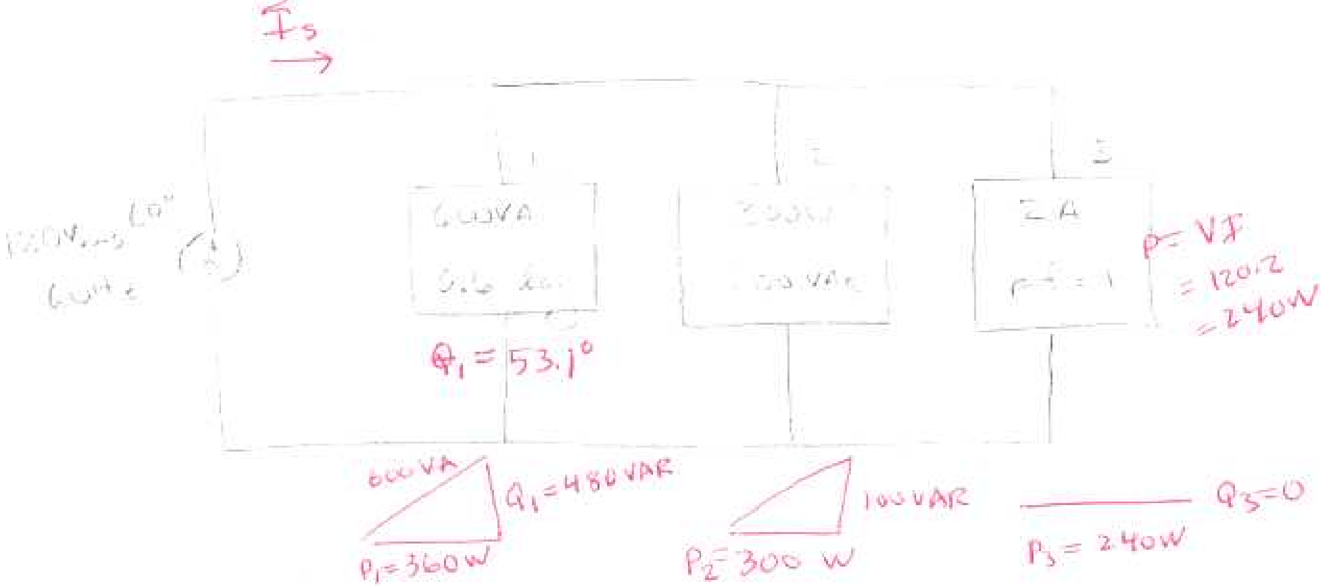
d. Which signal leads and by how much?

A leads by 45°

9. Find the Thevenin equivalent of the following AC circuit from the terminals indicated:



10. Given the following single-phase power system



a. Determine the magnitude of the source current

$P_{total} = 360 + 300 + 240 = 900$ W

$Q_{total} = 480 + 100 = 580$ VAR

$S_{total} = \sqrt{900^2 + 580^2} = 1071$ VA

$|\vec{I}_s| = \frac{S_{total}}{120} = 8.92\ A_{rms}$

b. What capacitance in parallel with the loads is required to raise the power factor to 0.95 lagging?

$\theta_2 = \cos^{-1}(0.95)$

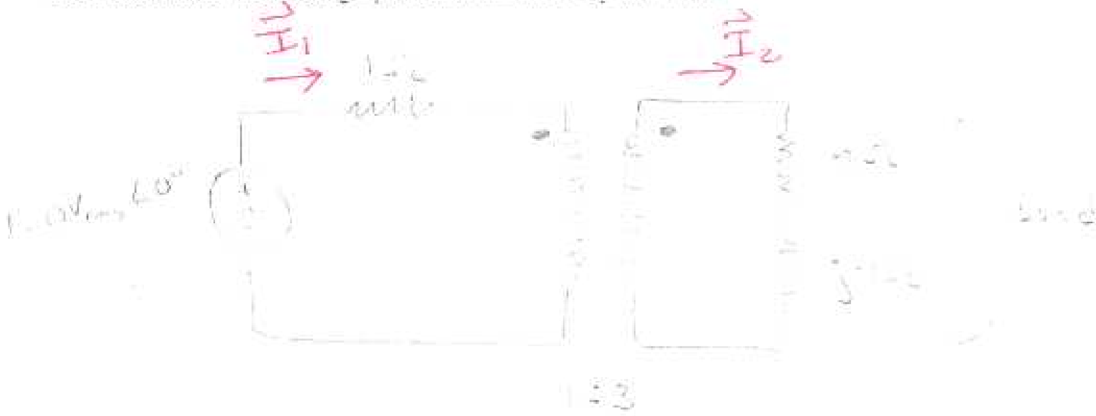
$Q_1 = 580$ VAR

$Q_2 = 900 \tan(18.2°) = 295.8$ VAR

$Q_c = Q_1 - Q_2 = -284.2$ VAR

$C = \frac{Q_c}{\omega V^2} = \frac{284.2}{377 \cdot 120^2} = 52.3\,\mu F$

11. Determine the average power consumed by the load:



$$Z_R = \frac{1}{3^2}(9+j9) = 1+j1$$

$$\vec{I}_1 = \frac{120\angle 0^\circ}{1+1+j} = 53.67\angle -26.6^\circ \text{ A}$$

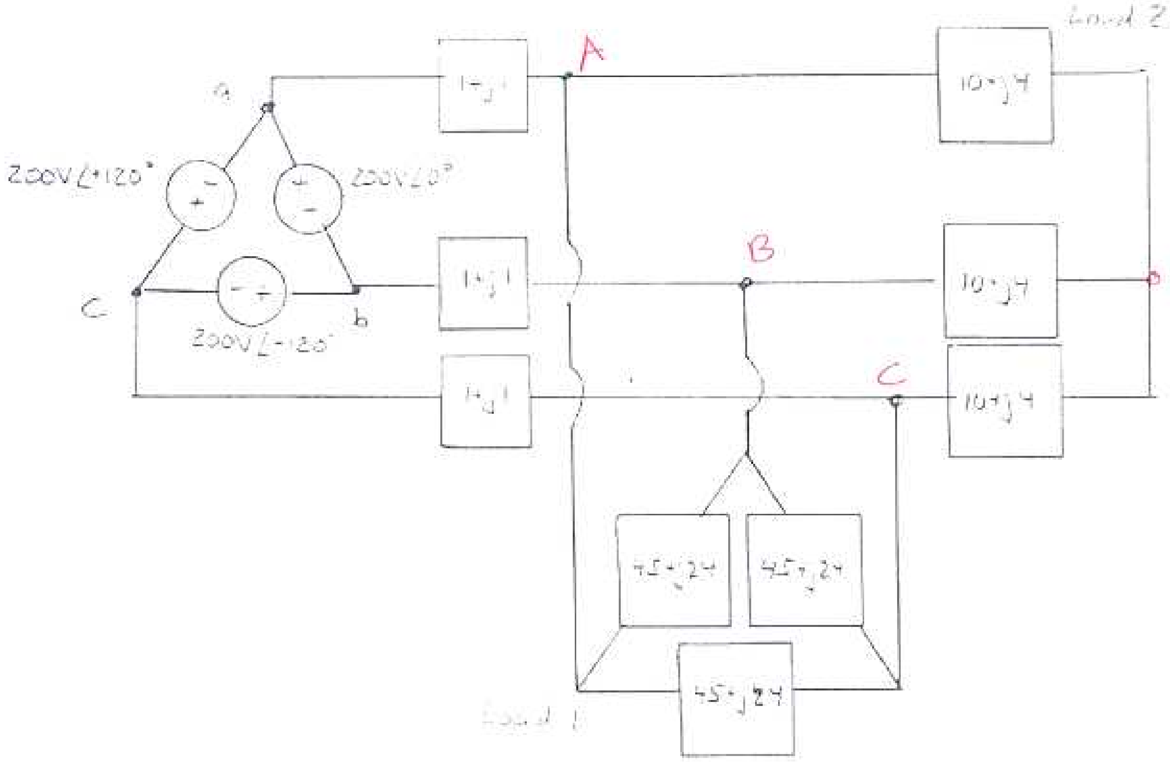
$$\vec{I}_2 = \frac{1}{3}\cdot\vec{I}_1 = 17.89\angle -26.6^\circ \text{A}$$

in the load, 9 Ω is the only element to dissipate average power (P)

$$P_{load} = |\vec{I}_2|^2 R$$

$$= (17.89)^2 \cdot 9 = \boxed{2880 \text{ W}}$$

12. Given the following 3-phase system



a. Find the total average and reactive power supplied to the 2 loads (combined).

Convert load 1 to Y-connection $Z_{\Delta_1} = 45+j24 \rightarrow Z_{Y_1} = 15+j8$

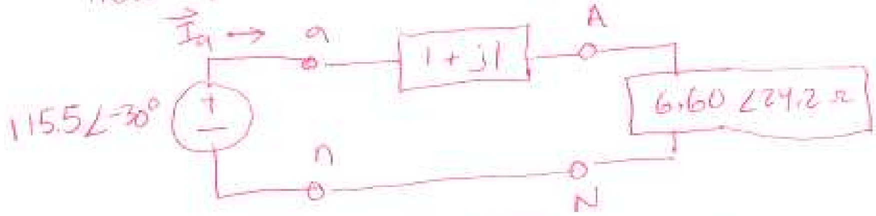
both loads 1 and 2 are Y-connected, combine them in parallel, to create a combined load Z_Y

$Z_Y = (15+j8) \| (10+j4) = 6.603\angle 24.2^\circ\ \Omega$

- convert source from $\Delta \rightarrow Y$

$\vec{V}_{ab} = \sqrt{3}\ \vec{V}_{an}\angle 30 \Rightarrow \vec{V}_{an} = \frac{200\angle 0^\circ}{\sqrt{3}\angle 30^\circ} = 115.5\angle -30^\circ$

now we can draw a single-phase equivalent, thus $\vec{I}_a$



$\vec{I}_a = \frac{115.5\angle -30^\circ}{1+j1 + 6.603\angle 24.2}$

$= 14.54\angle -57.9^\circ\ A$

Thus $\vec{S}_{Total} = 3\vec{V}_{AN}\vec{I}_a^* = 3|I_a|^2 Z_{load}$

$= 3|14.54|^2 \cdot 6.60\angle 24.2^\circ =$ **3819 + 1719 VA**

b. Find the line voltage at the loads.

$\vec{V}_{AN} = \vec{I}_{a'} \cdot (6.603 \angle 24.2^\circ) = 96.0 \angle -33.6^\circ$

$\vec{V}_{AB} = \sqrt{3}\ \vec{V}_{AN} \angle 30^\circ$

$\vec{V}_{AB} = 166.3 \angle -3.6^\circ$ V

$\vec{V}_{BC} = 166.3 \angle -123.6$ V

$\vec{V}_{CA} = 166.3 \angle 116.4$ V