Homework 6

Due date: 29th Nov.

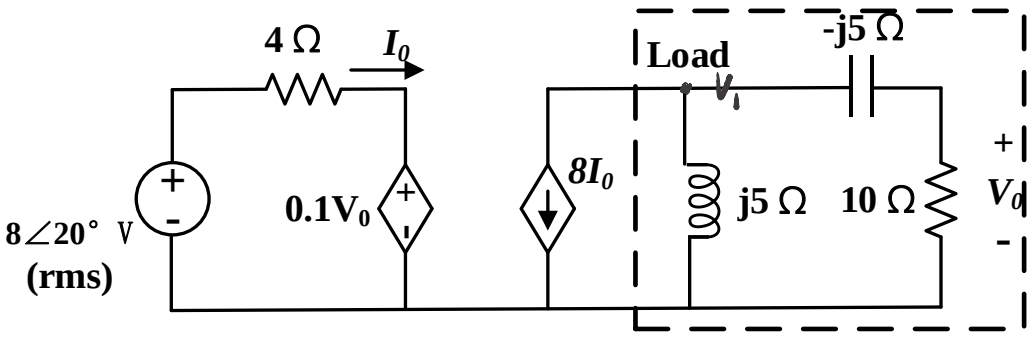
Turn in your homework in class

Rules:

- Work on your own. Discussion is permissible, but extremely similar submissions will be judged as plagiarism.
- Please show all intermediate steps: a correct solution without an explanation will get zero credit.
- Please submit on time. No late submission will be accepted.
- Please prepare your submission in English only. No Chinese submission will be accepted.

19'

1. For the circuit below, please find:
   (1) The average power absorbed by the load;
   (2) The reactive power absorbed by the load;
   (3) The complex power **S** absorbed by the load;
   (4) The power factor pf of the load.



6'

1) $8\angle 20° = 4I_0 + 0.1V_0 \Rightarrow 4I_0 = 8\angle 20° - \frac{1}{10-j5} V_1$

$8I_0 + \frac{V_1}{j5} + \frac{V_1}{-j5+10} = 0 \Rightarrow V_1 = 20\sqrt{10}\angle -51.5°$

$V_0 = \frac{10}{10-j5} V_1$

$I_0 = \sqrt{2}\angle 65°$

$I_L = -8I_0 = 8\sqrt{2}\angle -115°$ 2'

$\Rightarrow P = 20\sqrt{10}\cdot 8\sqrt{2}\cos(-51.5°+115°) = 320.06$ W 2'

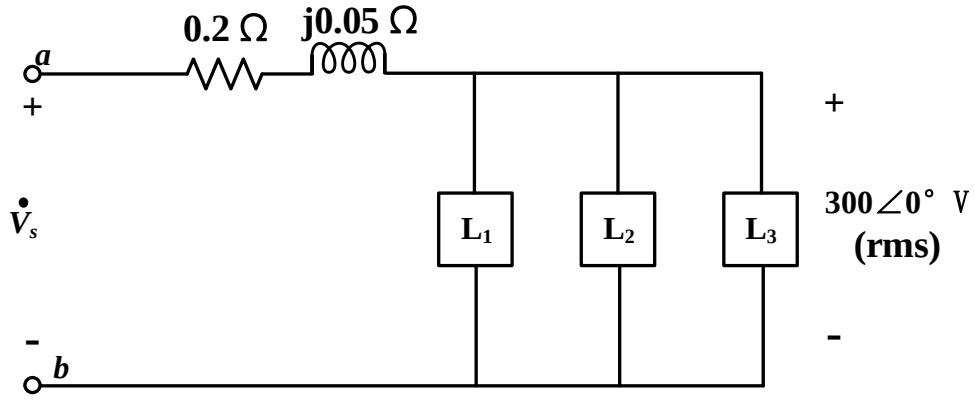
2) $Q = 20\sqrt{10}\cdot 8\sqrt{2}\sin(-51.5°+115°) = 639.97$ Var 3'

3) $S = P + jQ = 320.06 + j639.97$ VA 3'

4) $p.f. = \cos(\theta_v - \theta_i) = \cos(-51.5°+115°) = 0.45$ 3'

2. For the three-load circuit shown below, L_1 absorbs 3 kW at unity power factor; L_2 absorbs 5 kVA at 0.8 leading; L_3 absorbs 5 kW and delivers 6 kvars.
   (1) Calculate the voltage $\dot{V}s$.
   (2) Calculate the average power and reactive power associated with the line impedance (0.2Ω+j0.05Ω).
   (3) Calculate the average power and reactive power between port **a** and port **b**.

21'



1) $S_1 = 3 + j0$ kVA

3' $S_2 = 4 - j3$ kVA $\Rightarrow S_T = S_1 + S_2 + S_3 = 12 - j9$ kVA 2'

$S_3 = 5 - j6$ kVA

$300\,\tilde{I}_L^* = (12 - j9) \times 10^3$

$\tilde{I}_L = 40 + j30$ A 2'

$\therefore V_s = 300\angle 0° + (40 + j30)(0.2 + j0.05) = 306.5 + j8$ 2'

$= 306.6\angle 1.5°$ V

2) $|I_L| = 50$

$P_l = 2500 \times 0.2 = 500$ W 3'

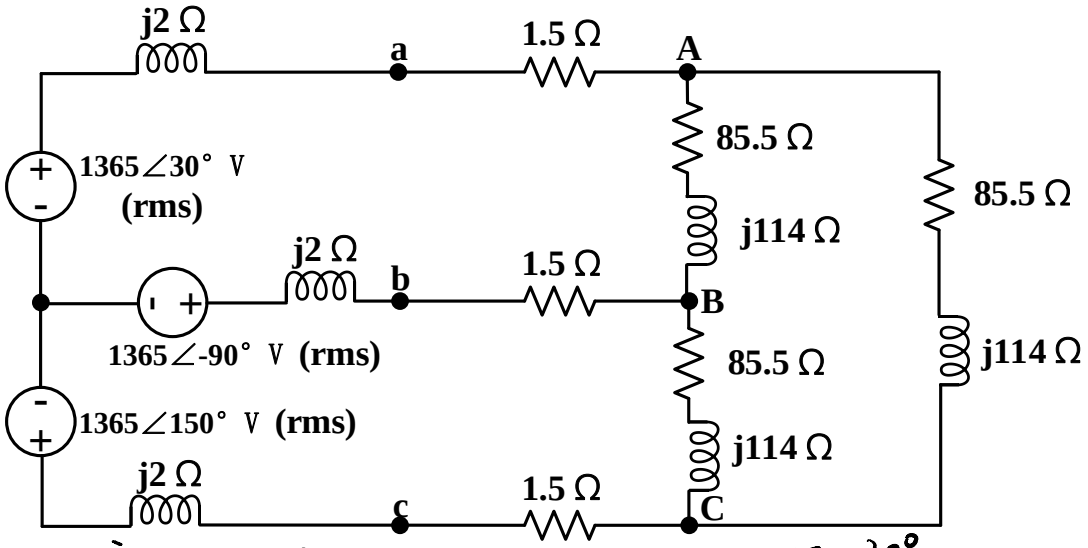
$Q_l = 2500 \times 0.05 = 125$ VAr 3'

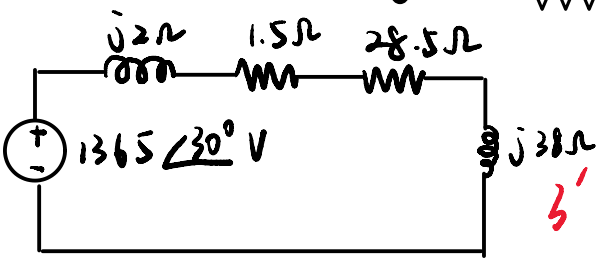
3) $P_{ab} = 12000 + 500 = 12.5$ kW 3'

$Q_{ab} = -9000 + 125 = -8.875$ kVAr 3'

3. For the circuit below,
   (1) Find $\dot{I}_{AB}$, $\dot{I}_{BC}$, $\dot{I}_{CA}$, and $\dot{V}_{CA}$ in the circuit.
   (2) What percent of the average power delivered by the three-phase source is dissipated in the three-phase load?

21'





2'

$$I_{aA} = \frac{1365\angle 30^\circ}{30+40j} = 27.3\angle -23.13^\circ \text{ A}$$

3' $$I_{CA} = \frac{I_{aA}}{\sqrt{3}}\angle 150^\circ = 15.76\angle 126.87^\circ \text{ A}$$

3' $$V_{CA} = I_{CA}\cdot(85.5+j114) = -2245.8 \text{ V}$$

3' $$I_{AB} = I_{CA}\angle -120^\circ = 15.76\angle 6.87^\circ \text{ A}$$

3' $$I_{BC} = I_{CA}\angle -240^\circ = 15.76\angle -113.13^\circ \text{ A}$$

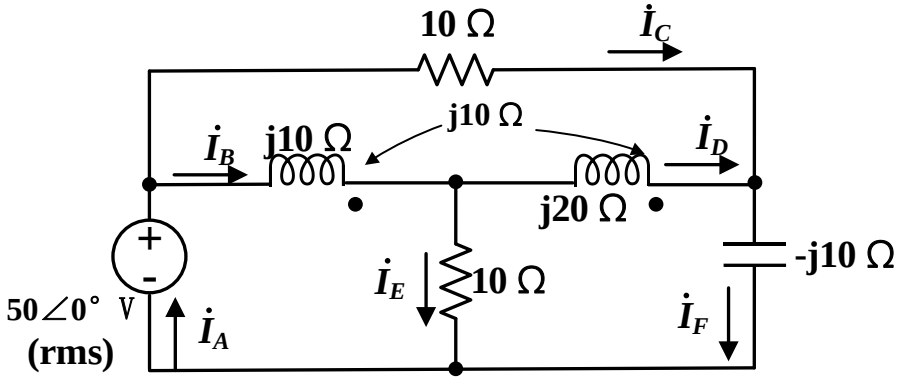
2) $$S_{g/\phi} = -1365\angle 30^\circ \, I_{aA}^{*} = -22358.75 - j29811.56 \text{ VA}$$

$$\therefore P_{deliver} = 22.359 \text{ kW}$$ 2'

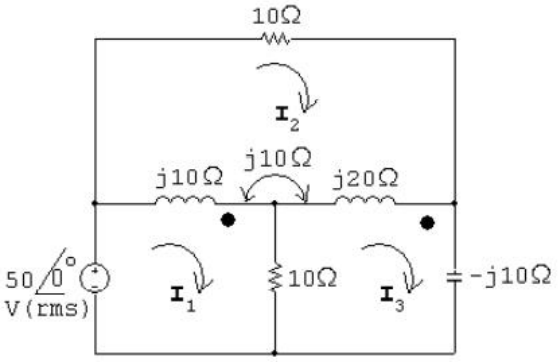
$$P_{dissipate} = |I_{aA}|^2 \cdot 28.5 = 21.241 \text{ kW}$$ 2'

$$\therefore \eta = \frac{21.241}{22.359} \times 100\% = 95\%$$ 3'

4. For the circuit below, please find:
   (1) Current $\dot{I}_D$, $\dot{I}_E$, and $\dot{I}_F$
   (2) The complex power on the capacitor, and the power factor pf of the capacitor.



1)



$$50 = j10(\mathbf{I}_1 - \mathbf{I}_2) + j10(\mathbf{I}_3 - \mathbf{I}_2) + 10(\mathbf{I}_1 - \mathbf{I}_3)$$

$$0 = 10\mathbf{I}_2 + j20(\mathbf{I}_2 - \mathbf{I}_3) + j10(\mathbf{I}_2 - \mathbf{I}_1) + j10(\mathbf{I}_2 - \mathbf{I}_1) + j10(\mathbf{I}_2 - \mathbf{I}_3)$$

$$0 = -j10\mathbf{I}_3 + 10(\mathbf{I}_3 - \mathbf{I}_1) + j20(\mathbf{I}_3 - \mathbf{I}_2) + j10(\mathbf{I}_1 - \mathbf{I}_2)$$

Solving,

$$\mathbf{I}_1 = 5.5 + j0.5\,\text{A(rms)}; \quad \mathbf{I}_2 = 3 + j2\,\text{A(rms)}; \quad \mathbf{I}_3 = 2 + j2\,\text{A(rms)}$$

$\mathbf{I}_a = \mathbf{I}_1 = 5.5 + j0.5\,\text{A}$ $\quad$ $\mathbf{I}_b = \mathbf{I}_1 - \mathbf{I}_2 = 2.5 - j1.5\,\text{A}$

$\mathbf{I}_c = \mathbf{I}_2 = 3 + j2\,\text{A}$ $\quad$ $\mathbf{I}_d = \mathbf{I}_3 - \mathbf{I}_2 = -1\,\text{A}$

$\mathbf{I}_e = \mathbf{I}_1 - \mathbf{I}_3 = 3.5 - j1.5\,\text{A}$ $\quad$ $\mathbf{I}_f = \mathbf{I}_3 = 2 + j2\,\text{A}$

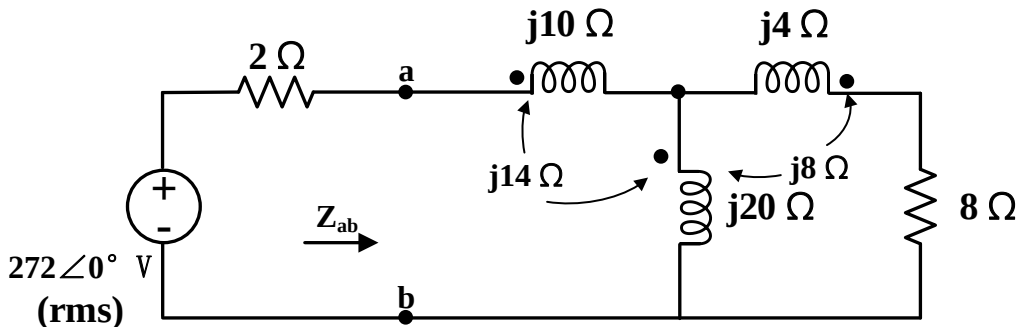
2) $V_f = -j10 I_f = 20 - j20\,V$

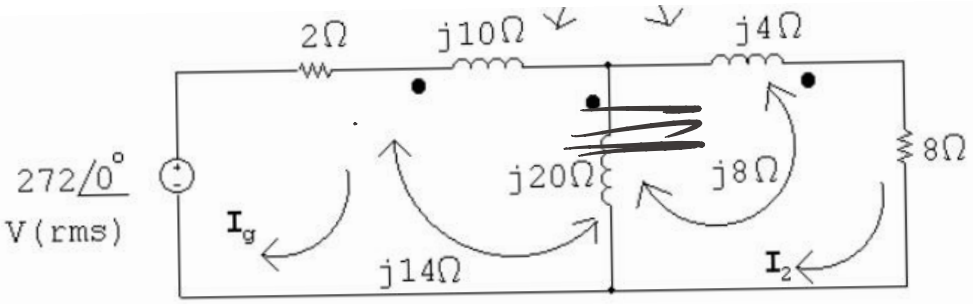
$S_f = V_f I_f^* = 0 - j80\,VA$

$pf = \cos(135° - 45°) = 0.$

18'

5. For the circuit below:
   (a) Find the average power delivered to the 8Ω resistor.
   (b) Find the average power generated by the ideal sinusoidal source
   (c) Find the impedance of Z_{ab}





$$272\underline{/0^\circ} = 2\mathbf{I}_g + j10\mathbf{I}_g + j14(\mathbf{I}_g - \mathbf{I}_2)$$
$$+j14\mathbf{I}_g - j8\mathbf{I}_2 + j20(\mathbf{I}_g - \mathbf{I}_2)$$
$$0 = j20(\mathbf{I}_2 - \mathbf{I}_g) - j14\mathbf{I}_g + j8\mathbf{I}_2 + j4\mathbf{I}_2$$
$$+j8(\mathbf{I}_2 - \mathbf{I}_g) + 8\mathbf{I}_2$$

4'

Solving,

$I_g = 14.48\angle -56.1^\circ$ A $I_2 = 14.9\angle -44.79^\circ$ A 3'

$P_{8\Omega} = 14.9^2(8) = 1776$ W 3'

b) P_g (developed) $= 272 \times 14.48 \cos(-56.1^\circ) = 2196.7$ W 4'

c) $Z_{ab} = \frac{V_g}{I_g} - 2 = \frac{272}{14.48\angle -56.1^\circ} - 2 = 17.75\angle 61.5^\circ\ \Omega$ 4'