ECE 325, Fall 2016, Test 1

Problem 1 (35 points, 5 points each): Circle ALL correct statements (reasons are NOT required)

a. For long distance power transmission, HVAC is always a more economical option than HVDC. *(At present, the cross-over point for HVDC to be competitive is around 500km for overhead lines or 50km for underground/submarine cables.)*

b. Natural gas is the 2nd largest energy resource of electricity generation for the overall US power grids.

c. Both gas turbine plants and pumped-storage hydropower plants can be used as peak-generation plants

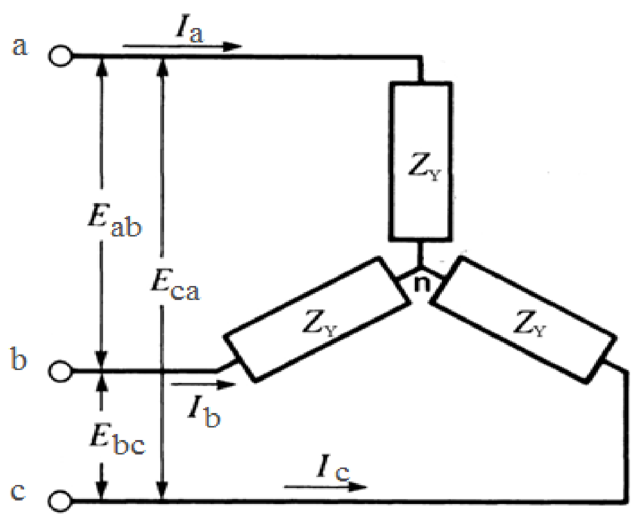
d. The overall efficiency of any thermal power plant cannot exceed 50% *(The efficiency of a combined-cycle power plant may exceed 60%)*

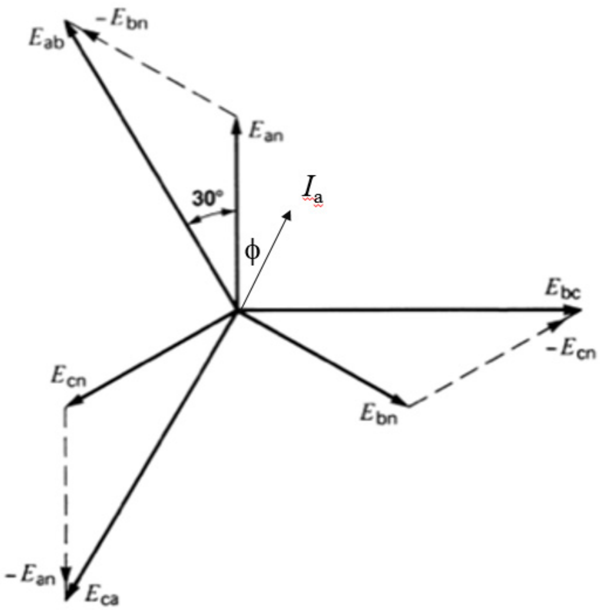
e. Usually, a nuclear power plant has a higher efficiency than a coal-fired power plant. *(lower)*

f. The highest voltage level of AC power transmission systems in USA is 500kV *(765kV)*

g. The 3-phase complex power of the wye-connected load equals $\sqrt{3}E_{ab}I_a^*$ ($\sqrt{3}E_{ab}I_a^* \cdot 1\angle -30^\circ$)

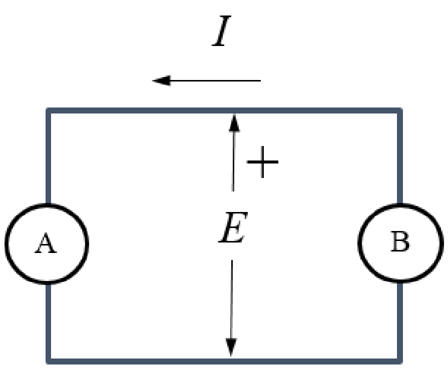
Only b and c are correct (5 pts each).

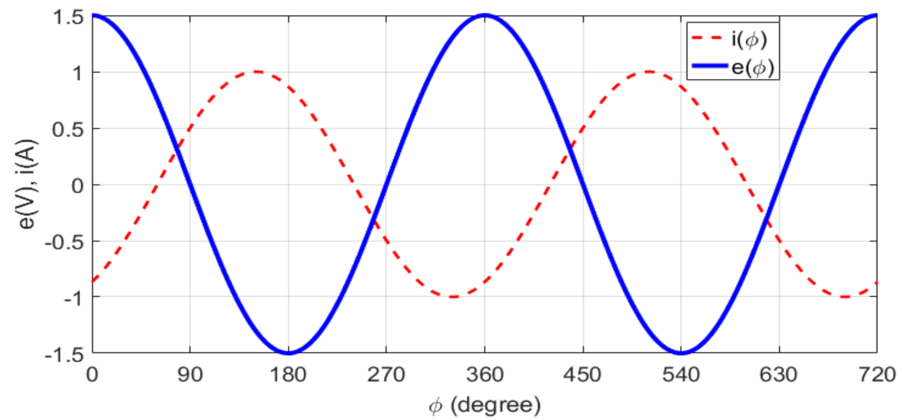


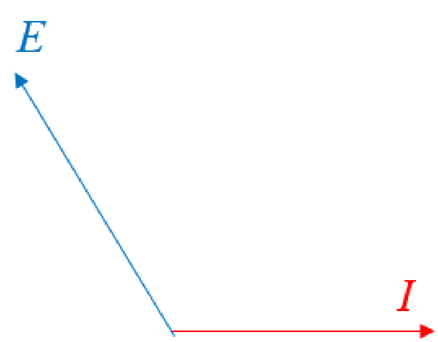


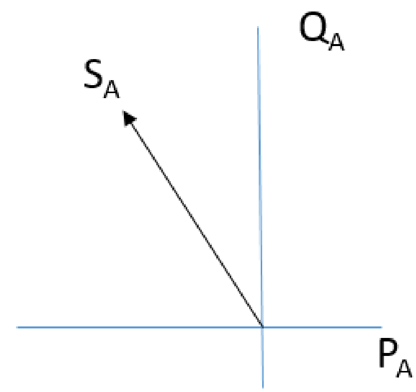
Problem 2 (10 points): A circuit connecting devices A and B has current *I* and voltage *E* as defined in the figure. Their instantaneous values, *i* and *e*, are given in the plot. Regarding the current operating condition of the circuit, circle the correct statements:

1) Device A is the active source
2) Device B is the active source
3) Device A is the reactive load
4) Device B is the reactive load





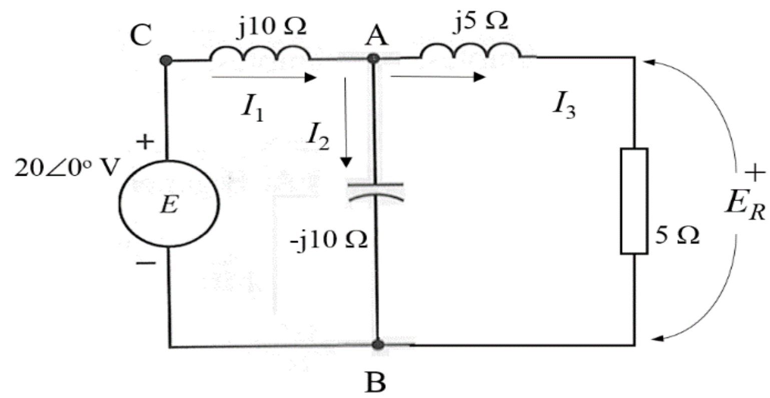




5 pts for choosing 1), not 2)
5 pts for choosing 3), not 4)

Problem 3 (30 points): The circuit shown in the figure is powered by a 20V AC source. Calculate

a. branch currents I_1, I_2 and I_3 as defined in the figure
b. the voltage E_R across the resistor
c. the complex power supplied by the source E
d. the reactive power supplied by the capacitor
e. Draw the phasor diagram about E, E_R, I_1, I_2 and I_3



a. (10 pts for Steps)

Method 1: Z + 2 KVL/KCL equations;

Method 2: 3 KVL/KCL equations

Z_1=j10, Z_2= -j10, Z_3=5+j5

Z= Z_3//Z_2+Z_1 = (5+j5)×(-j10)/(5+j5-j10) +j10 =10+j10 Ω

I_1=E/Z=20/(10+j10)=1 -j = 1.41∠-45° A **(1 pt + 1 pt)**

KVL: E - I_1Z_1-I_2Z_2=0

I_2= (E-I_1Z_1)/Z_2= 1+j =1.41∠ 45° A **(1 pt + 1 pt)**

I_2 Z_2-I_3Z_3=0

I_3= I_2 Z_2/Z_3 = -j2 =2∠ -90° A **(1 pt + 1 pt)**

(Validated by KCL: I_1+I_2+I_3=0)

b. (1 pt for the equation)

E_R=I_3R=10∠ -90° V **(1 pt + 1 pt)**

c. (1 pt for the equation)

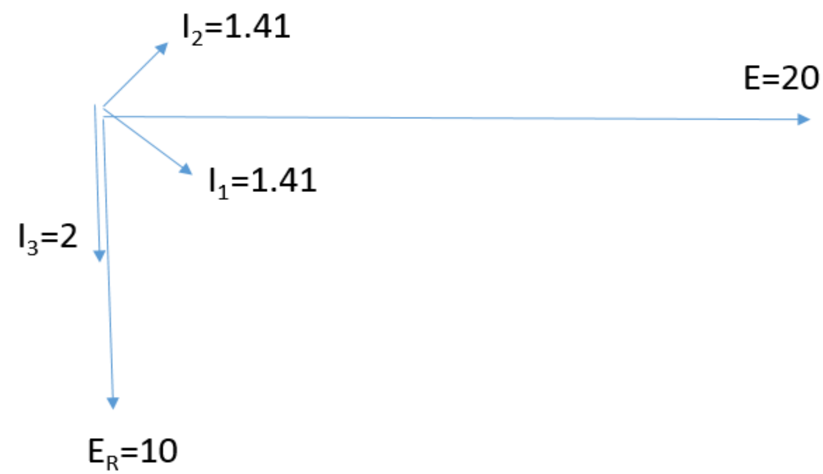
S=EI_1^*=20×(1+j)=20W+ j20 var **(1 pt + 1 pt)**

d. (1 pt for the equation)

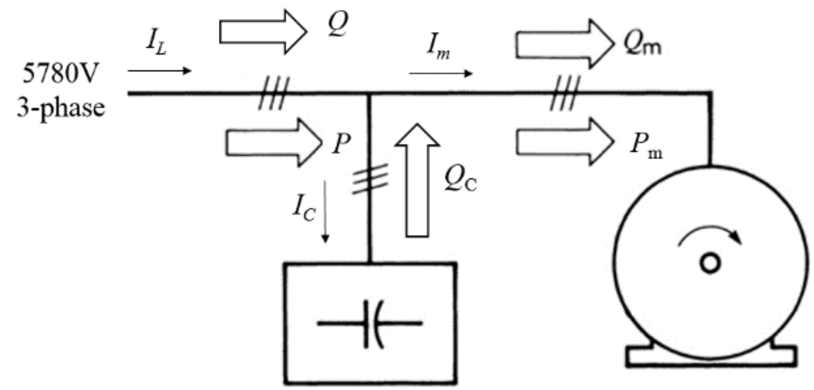
S_C=$|I_2|^2Z_2$=2×-j10= -20j var

Supply +20var **(1 pt for "20" + 1 pt for "+")**

e. Phasor diagram **(5 pts: 1 pt per phasor)**



Problem 4 (35 points): A wye-connected motor is connected to a 5780V (line-to-line voltage) 3-phase, 60Hz transmission line. A delta-connected capacitor bank rated at Q_C=100kvar is also connected to the line to provide reactive power support. If the motor produces an output of 161kW at 93% efficiency and a power factor of 0.866 (lagging). I_L is the transmission line current, I_C is the line current drawn by the capacitor bank and I_m is the line current drawn by the motor. Calculate the following



a. The reactive power Q_m absorbed by the motor
b. The complex power $S=P+jQ$ supplied by the transmission line
c. RMS values of I_L, I_C and I_m
d. Draw a phasor diagram about I_L, I_m, I_C and line-to-neutral voltage E_{LN} of the transmission line for one phase

a. (6 pts for equations)

$\phi_m=\cos^{-1}(0.866)=30^o$ **1 pt**

$P_m=161/0.93 = 173$ kW **2 pt**

$Q_m=P_m\tan(\phi_m)=173\times1.73=$100 kvar **1 pt**

b. (4 pts for equations)

$S_m=173+j100$ kVA

$S=S_m- j\,Q_C=$173 +j 0 kVA **1 pt + 1 pt**

c. (6 pts for equations)

$|I_L|=|S|/(E_L\times1.73)=$17.3 A **1 pt**

$|I_m|=|S_m|/(E_L\times1.73)=$20A **1 pt**

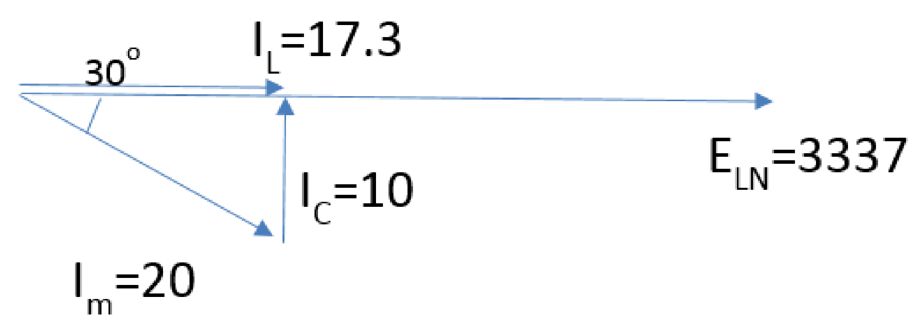
$|I_C|=|Q_C|/(E_L\times1.73)=$10A **1 pt**

d. (4 pts for equations)

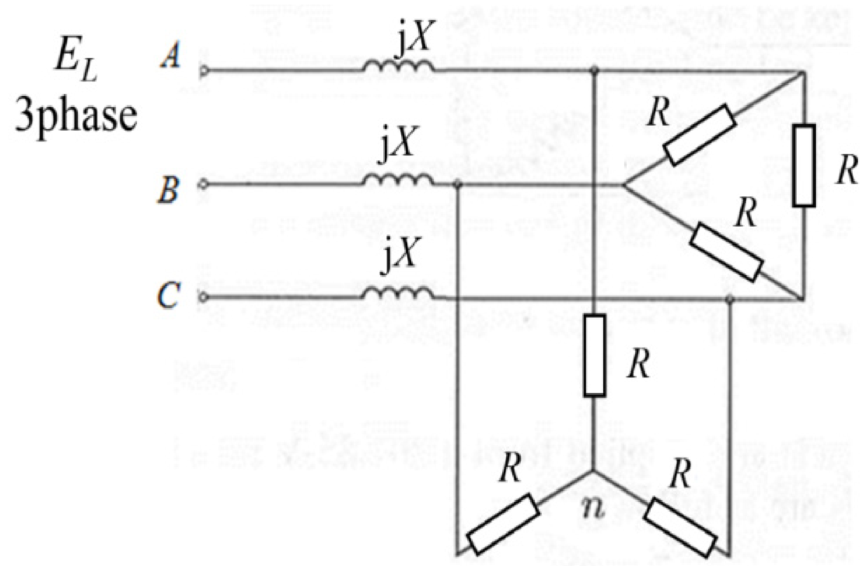
$E_{LN}=E_L/1.73=$3337 V **1 pt**

$\phi=\tan^{-1}(Q/P)=0^o$ **1 pt**

Phasor diagram **4pts: 1 pt per phasor**



Problem 5 (10 points): A three-phase line having line-to-line voltage E_L is supporting both delta-connected resistances and wye-connected resistances through series reactors. All six resistances are identical and equal to R. All reactors have reactance X. Give the formulas on



a. the magnitude of each line current
b. the total three-phase complex power supplied by the line

a.

$$Z = R // \frac{R}{3} + jX = \frac{R}{4} + jX$$

2 pts

$$|I_L| = \left| \frac{E_L}{\sqrt{3}(\frac{R}{4} + jX)} \right|$$

4 pts

b.

$$S = \frac{3|E_L/\sqrt{3}|^2}{Z^*} = \frac{|E_L|^2}{\frac{R}{4} - jX}$$

4 pts