ECE 325, Fall 2016, Test 2

Problem 1 (12 points, 3 points each): True or False?

a. Like the electrical conductivity σ of a conducting material, the permeability μ of a magnetic material is also a constant. Not constant

b. When a source delivers electric power through a transformer to a load of unity power factor, the voltage regulation of the transformer is positive.

c. If a transmission line increases its length, R, X_L and X_C of its equivalent lumped circuit will all increase. X_C decreases since C increases

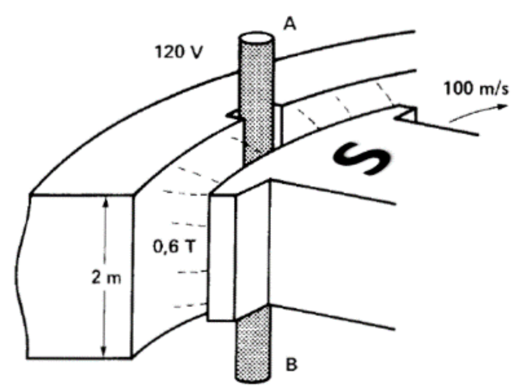
d. An inductive line having reactance of X delivers power to a load that is resistor of $R=X/2$. If R decreases, the line will deliver more power to the load. Once R decreases beyond the "nose" point (where $R=X$), power decreases.

Problem 2 (9 points) A stationary conductor AB is placed in a rotating magnetic field. At the instant show in the figure, circle the correct statement(s):

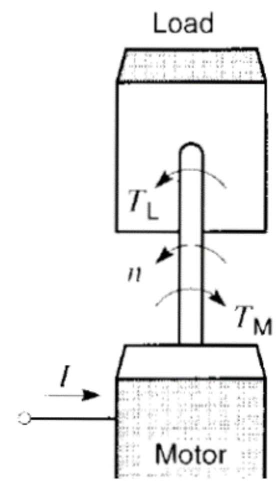
1) The current induced in the conductor is from A to B.

2) The force on the conductor is to the right.

3) The force on the moving S pole is to the left.

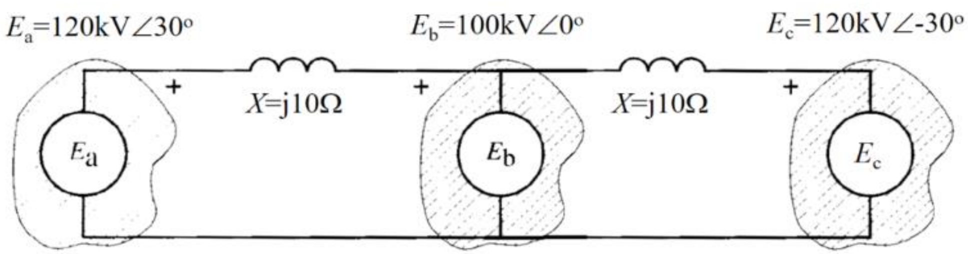


Problem 3 (9 points) Consider a load coupled to a motor by means of a shaft. The load exerts a constant load torque T_L. When the mechanical torque T_M developed by the motor and the rotation of the shaft have opposite directions as shown in the figure, circuit the correct statement(s)



1) There must be $T_M < T_L$. At this time instant, T_M may be >, = or < T_L
2) The speed n must decrease. n may increase if $T_L > T_M$
3) The power flow must be from the load to the motor. $T_m \times n < 0$

Problem 4 (9 points) In a three-region power system, region **a** is connected to both region **b** and region **c** by two tie lines having the same reactance X. Voltage phasors of three regions are given in the figure. Circle the correct statement(s):



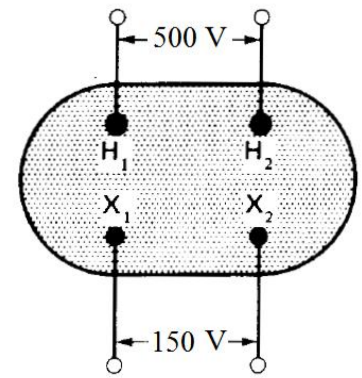
1) The net active power consumption of region **b** is positive.
   $P_{ab} = P_{bc} = 120 \times 100 \times \sin 30^{\circ}/10$
2) If we increase the angle of E_b from 0° to 5° without changing the angles of E_a and E_c, region **b** will become an active power source in the system.
3) Adding a shunt capacitor to region **b** can increase the power transmission capacities between regions **a** and **b** and between regions **b** and **c**.

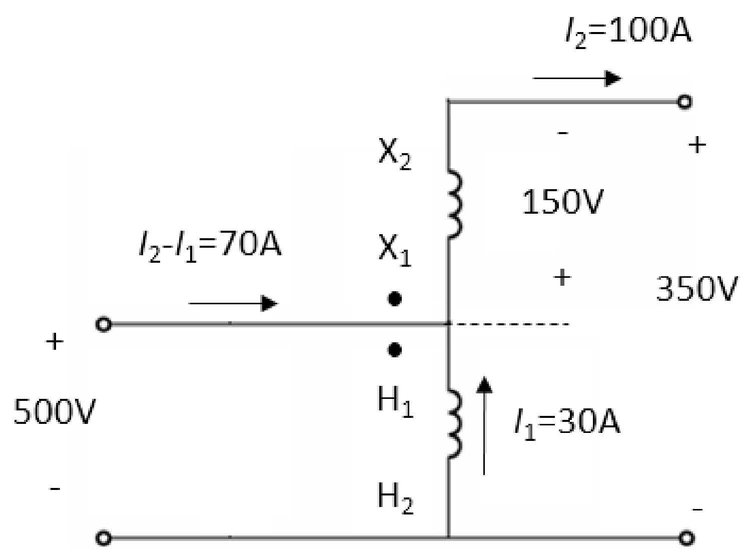
$P_{ab,\ max} = |E_a| \times |E_b|/X$ $P_{bc,\ max} = |E_b| \times |E_c|/X$

Problem 5 (16 points) A single-phase 500V/150V transformer has a rating of 15kVA at 60Hz.

a. Indicate how to reconnect the terminals to make a step-down autotransformer with 500V primary to 350V secondary: on the figure, show which terminals to be short-circuited and which to connect with a source or load

b. What is the rating of this new 500V/350V autotransformer?





$|S_i| = 500 \times 70 = 35\text{kVA}$

$|S_o| = 350 \times 100 = 35\text{kVA}$

a. 9 pts

Solution-1: Short circuit X1 and H1 (3), connect H1 & H2 to source (3) and connect X2 and H2 to load (3)

Solution-2: Short circuit X2 and H2 (3), connect H1 & H2 to source (3) and connect X1 and H1 to load (3)

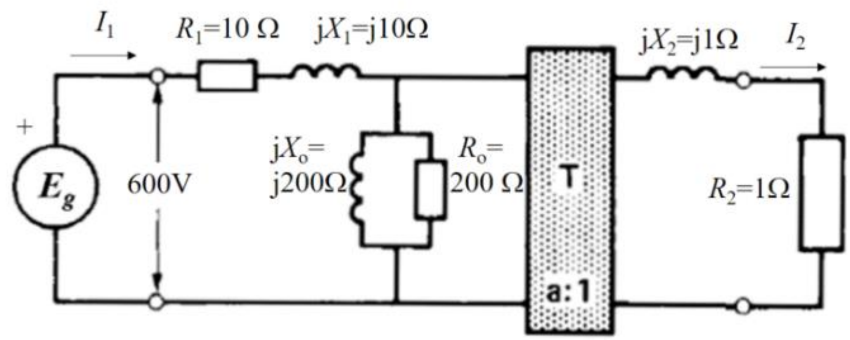
b. 7 pts

I_H=15000/500=30A (2),

I_X=15000/150=100A (2)

New Rating=500×(100-30)=350×100=35kVA (3)

Problem 6 (30 points): The shaded box *T* is an ideal transformer connected in the circuit. Calculate I_1 and I_2.

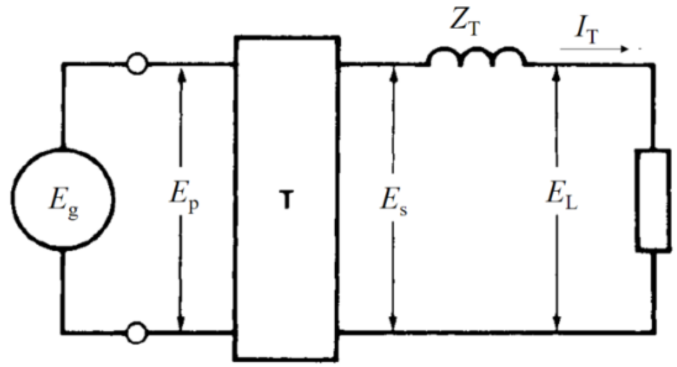


a=10

Referred to the P side:		Or referred to the S side:	
$Z_2=1+j1\ \Omega$		$Z_2=1+j1\ \Omega$	
$Z_{2p}=Z_2 x100=100+j100\ \Omega$	5	$Z_{1s}=(10+j10)/100=0.1+j0.1\ \Omega$	4
$Z_o=200xj200/(200+j200)= 100+j100\ \Omega$	3	$Z_o=200xj200/(200+j200)= 100+j100\ \Omega$	2
$Z_{o//2}=Z_o//Z_{2p}=50+j50\ \Omega$	3	$Z_{os}=1+j1\ \Omega$	2
$Z=Z_1+Z_{o//2}=10+j10+50+j50=60+j60\ \Omega$	3	$Z_{o//2}=Z_{os}//Z_2=0.5+j0.5\ \Omega$	2
$I_1=E_g/Z=5-j5$ A	5	$Z_s=Z_{1s}+Z_{o//2}=0.1+j0.1+0.5+j0.5=0.6+j0.6\ \Omega$	2
$E_1=E_g-I_1 xZ_1=500$ V	3	$E_{gs}=600/10=60$ V	2
$E_2=E_1/a=50$ V	3	$I_{1s}=E_{gs}/Z_s=50-j50$ A	3
$I_2=E_2/Z_2=25-j25$ A	5	$I_1=I_{1s}/10=5-j5$ A	5
		$E_2=E_{gs}-I_{1s} xZ_{1s}=50$ V	3
		$I_2=E_2/Z_2=25-j25$ A	5

Problem 7 (35 points): A 3-phase step-up transformer is rated 600MVA, 34.5kV/345kV and 60Hz, and has an impedance of 10%. It steps up the voltage of a 3-phase generator to power a 3-phase line. When the HV side of the transformer delivers 330MVA at 380kV with a unity power factor.

a. Its equivalent circuit per phase is shown in the figure using the nominal voltage and power rating of the transformer as base quantities. Calculate the per-unit values of the voltage E_L across the load and the voltage E_g across the generator terminals.
b. Calculate the actual line-to-line voltage across the generator terminals in volt.



You may choose any reference of phasors

a. a=345/34.5=10

E_B=345/1.73=199.4kV 3

S_B=600/3=200MVA 3

Z_T (pu)=0.1j pu 1

$|S_L|$=330/3=110MVA 3

$|S_L|$ (pu) = S_L/S_B = 110/200 or 330/600= 0.55 pu 3

S_L = 0.55 pu 1

E_L=380/1.73=219.7kV 3

E_L(pu)= E_L/E_B =219.7/199.4 = 1.101 pu

or =380/345=1.101 pu 3

I_L (pu) = $(S_L/E_L)^*$= 0.5 pu 3

E_S (pu) = E_L(pu) + I_L (pu) × Z_T (pu)

= 1.101+j0.05=1.103 $\angle 2.60^\circ$ pu 6

b. $|E_g|$= $|E_S|$ (pu) × 34.5= 38.04 kV 6