Homework # 4

Due: Monday, July 10th

Question 1. (5 points) Describe the advantages of per-unit system.

Question 2. (5 points) How tap changing transformers help control the receiving end voltage in a power system.

Question 3. (5 points) Define and explain parameters inductance and capacitance.

Question 4. (5 Points) Explain about skin effect in AC transmission.

Question 5. (5 points) How salient-pole round-rotor synchronous machines are different?

Question 6. (5 points) Describe the purpose of transposition of transmission lines.

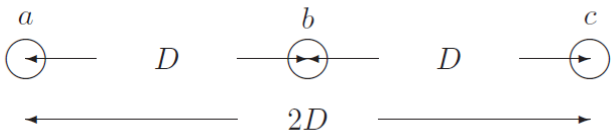
Question 7. (25 points) A 3-phase, 318.75 kVA, 2300 V
Synchronous generator (alternator) has an armature resistance of .35 ohm/phase and a synchronous reactance of 1.2 ohm/phase. Determine the no-load generated voltage and the voltage regulation at

a) Full-load kVA, 0.8 pf lagging and rated voltage
b) Full-load kVA, 0.6 pf leading and rated voltage

Question 8. (25 points) A 60 MVA, 69.3kV, 3-phase synchronous generator has a synchronous reactance of a 15 ohm/phase and negligible armature reactance.

a) The generator is delivering rated power at 0.8 pf lagging at the rated terminal voltage to an infinite bus bar. Determine the magnitude of the generated emf per phase and the power angle delta.
b) If the generated emf is 36kV per phase, what is the maximum 3-phase power that the generator can deliver before losing its synchronism.

Question 9. (20 points) A 3-phase, 60Hz transposed transmission line has a flat horizontal configuration as shown in figure 1. The line reactance is 0.486 Ohm/km. The conductor geometric mean radius is 2cm. Determine the phase spacing D in meters.



1)
makes calculations easier when dealing with a system that has multiple voltage levels
removes most factors of 3 and sqrt3 from calculations
gives voltage drop diractly as a percentage
gives an easy to understand relative estimate of voltage, current, impedance, and power
2)
They mechanically connect and disconnect along one of the inductors to change the ratio of the transformer, allowing for control over the output, and therefore control over the voltage received by the users of the system
3)
Inductance is when a conductor resists a change in current because of the energy stored in it's magnetic field, giving us the relation V=dI/dt
Capacitance is when a conductor resists a change in voltage because of the energy stored in it's electric field, giving us the relation I=dV/dt
4)
The skin effect explains how when transmitting alternating current, the charges in the wire repel each other toward the surface of the conductor, making surface area much more important for conductivity than cross-sectional area.
5)
Salient pole machines have a non-uniform air gap and project the poles out from the surface of the rotor. They tend to be wider and shorter and are better for lower-speed operation. Round rotor machines have a uniform air gap, tend to be narrower and longer, and are better for high-speed operation.
6)
The purpose of transposition of power lines is to balance the induction of all the lines. Since the lines often aren't evenly spaced, they have uneven induction, which would create an uneven load, but transposition makes sure they all balance out to get a balanced load.
7)
V_phase=2300/sqrt3=1327.9V
a)
S=318750<36.87 VA
I_a=S*/3V_phase*=318750<-36.87/(3*1327.9)=80<-36.87 A
E_phase=1327.9+(.35+1.2j)(80<-36.87)=1409.2<2.44 V
no load voltage magnitude E=sqrt3 1409.2 = 2440.8 V
Voltage regulation=(2440.8-2300)/2300 = 6.12%
b)
S=318750<-53.13 VA
I_a=S*/3V_phase*=318750<53.13/(3*1327.9)=80<53.13 A
E_phase=1327.9+(.35+1.2j)(80<53.13)=1270.4<3.61 V
no load voltage magnitude E=sqrt3 1270.4 = 2200.4V
Voltage regulation=(2200.4-2300)/2300=-4.33%
8)
V_phase=69.3k/sqrt3=40kV
a)
S=60k<36.87 kVA
I_a=S*/3v_phase*=60M<-36.87/(3*40k)=500<-36.87 A
E_phase=40+15j(500<-36.87)=44.9<7.675 kV
48=3*46*40/15 sin delta
delta = 7.4947
b)
P_max=3|E||V|/X_s=3*36*40/15=288MW

9)
Z=sL
.486=60*2pi*L
L=.486/(60*2pi)=1.29*10^-3 H/km=1.29mH/km
L=.2*ln(GMD/GMR)mH/km
5L=ln(GMD/GMR)
e^5L=GMD/GMR
GMRe^5L=GMD
GMD=.02*e^(5*.0012)=.0201km=20.1m
D=GMD*2^(-1/3)=15.97m