

**Georgia Institute of Technology**  
**School of Electrical and Computer Engineering**

EE4321

Power System Engineering

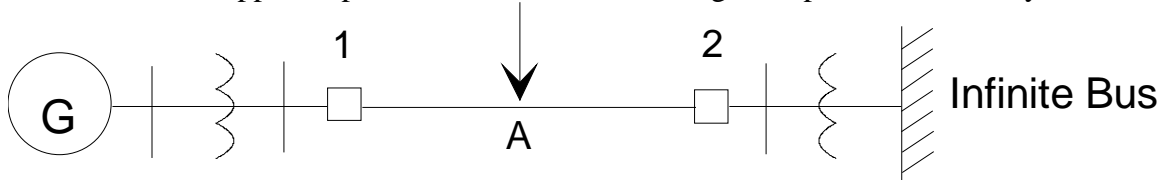
Spring 2009

Homework Assignment #4  
 Due February 26, 2009

**Problem P1:** The total generating capacity of the electric power grid in the US is approximately 1,000,000 MVA. Assume that on average the per unit inertia constant of the generators is  $H=3.2$  sec.

- a) Compute the total kinetic energy stored in the rotors of the generating units when they rotate at synchronous speed.
- b) Compute the kinetic energy of a 3000 lbs automobile moving at speed of 60 mph and compare it to the answer in (a) above. How many automobiles moving at a speed of 60 mph, 3000 lbs each will have total kinetic energy as the generating units in (a)?

**Problem P2:** A 3-phase synchronous machine is rated 300 MVA, 60 Hz, 18 kV. The transient reactance of the machine is 0.18 pu. It is connected to a 500 kV infinite bus via an 18 kV/230 kV, wye-wye connected step-up transformer, one 230 kV transmission line and a 230 kV/500 kV wye-wye connected auto-transformer as it is illustrated in Figure P2. The generator delivers at its terminals 250 MVA apparent power at rated terminal voltage and power factor unity.



**Figure P2**

Assume at time  $t=0$  a three-phase fault occurs at a point A along the transmission line. The fault is cleared in 3 cycles or 0.05 seconds by opening the breakers 1 and 2. At time  $t=0.10$  seconds after the breakers opened, the breakers 1 and 2 reclose. Assume that the fault was temporary, i.e. upon reclosing the system is faultless.

- (a) Compute the operating conditions of the system prior to the fault.
- (b) Compute the generator phase angle as a function of time in the time interval zero to 0.15 seconds.
- (c) Compute the electric power output of the generator immediately after the breakers reclose.

Additional data are:

18 kV/230 kV transformer: Power rating: 300 MVA,  $z_1 = j0.07$  pu (on its own rating).

Transmission line: Length: 60 miles long,  $z_1 = j0.65$  ohms / mile .

230kV/500kV auto-transformer: Power rating: 300 MVA,  $z_1 = j0.06$  pu (on its own rating).

Generator:  $z_d = j0.18$ ,  $H = 2.8$  sec