EE 303, Quiz 5, Spring 2017, Dr. McCalley; Name:_____
Time: 20 minutes, closed book, closed notes

1. (34 pts) A generator is connected to a transmission line through a transformer having a rated turns ratio (ratio of line-to-line voltages) of 20kV (generator side) to 100kV (transmission line side). The generator has a per unit reactance of 0.08 pu on a 20 kV, 50 MVA base. Select the base voltage on the transmission line side to be 110 kV.
   a. Compute the base voltage on the generator side.
   Solution:

$$V_{basegen} = 110kV \cdot \left[\frac{20kV}{100kV}\right] = 22kV$$

   b. Compute the pu reactance of the generator using a 100MVA system power base, for this system when the transmission side voltage base is 110 kV.
   Solution:

$$X_{pu2} = X_{pu1} \cdot \left[\frac{V_{base1}}{V_{base2}}\right]^2 \cdot \left[\frac{S_{base2}}{S_{base1}}\right] = 0.08 \cdot \left[\frac{20kV}{22kV}\right]^2 \cdot \left[\frac{100MVA}{50MVA}\right] = 0.1322$$

   This calculation could also be done this way:

$$X_{pu2} = X_{pu1} \cdot \left[\frac{V_{base1}}{V_{base2}}\right]^2 \cdot \left[\frac{S_{base2}}{S_{base1}}\right] = 0.08 \cdot \left[\frac{100kV}{110kV}\right]^2 \cdot \left[\frac{100MVA}{50MVA}\right] = 0.1322$$

2. (34 pts) A three-phase, 60 Hz generator has a synchronous reactance of $0.9\Omega/\phi$ and negligible resistance. The generator is delivering 50MW at 0.8 power factor lagging. The terminal voltage is 30kV line to line. Determine the excitation voltage per phase (angle and magnitude).

Solution:

$$V_t = \frac{30kV}{\sqrt{3}} = 17.32kV;$$

$$P = 50MW; \quad pf = 0.8 = \cos\theta \Rightarrow \theta = 36.87°$$

$$P = 3|V_t||I_a|\cos\theta \quad \Rightarrow \frac{P}{3\cdot|V_t|\cos\theta} = \frac{50\times10^6}{3\left(17.32\times10^3\right)\cdot(0.8)} = |I_a| = 1202.8A; \quad \Rightarrow I_a = 1202.8\angle -36.87°A$$

$$E_f = V_t + I_a\left(jX_s\right) = 17.32\times10^3\angle 0° + \left(1202.8\angle -36.87°\right)\cdot\left(j0.9\right)$$
$$= 17970.0 + j866V = 17991\angle 2.759°V$$

3. (32pts) A large inductor is connected in parallel with a resistive load, and both of them are directly connected to a synchronous generator. Draw the phasor diagram corresponding to the operation of the synchronous generator. Show phasors corresponding to $\bar{V}_t$, $\bar{E}_f$, $\bar{I}_a$, $jX_S\bar{I}_a$. Also show the power angle δ. Assume the phasor $\bar{V}_t$ is the reference.

   Solution:

The angle δ is between $\bar{E}_f$ and $\bar{V}_t$.