Homework 5

1. The key to the operation of AC machines is a rotating magnetic field. Explain what a rotating field is and how it is created using a three phase winding with balanced three-phase currents? What is the relative speed between stator and rotor field in such machines? How do we create create a rotating field in a single-phase induction motor?
2. For a synchronous generator with damper windings ignored,
    a. Write the primitive equations for the coupled circuit model
    b. Write the equations for the couple circuit model transformed to a synchronously rotating frame (Park Transformation)
    c. Write the equations for a steady state phasor model
3. Repeat problem 2 for an induction motor
4. In class we developed the coupled coil model for a three phase induction motor. Justify the form of the terms Lrr and Lsr submatrices as a function of rotor position
5. Explain what the Park transformation accomplishes in terms of modeling synchronous machines.

A synchronous generator is operating at synchronous speed. The stator currents are balanced positive sequence, 60 Hz.

a. Plot the stator currents

b. Apply Park's transformation and plot the d and q currents

c. Looking at the nature of coupling in the dqo domain tell me if you expect the stator current to induce voltage in the field

Now suppose a single-phase fault has occurred and the stator currents are Ia= Im cos(ωt), Ib=0 and Ic=0.

a. Plot the stator currents

b. Apply Park's transformation and plot the d and q currents

c. Looking at the nature of coupling in the dqo domain tell me if you expect the stator current to induce voltage in the field; at what frequency?

d. The voltage induced in the field in part c will create a current in the field. This current in turn will induce a voltage in the stator? What would the frequency of voltage induced in the d- a q- coils be? What is the frequency of the corresponding phase voltage induced in the stator?

Homework 6

1. A wye grounded, synchronous machine is operating at no load with rated voltage when a single-phase fault occurs on phase ‘a’. Damper windings are ignored.

   Modify my Mathcad Implementation or write a Matlab program to solve for and plot phase currents and field current for a SLG fault in the time domain using the dqo model.

2. A synchronous generator is rated 100 MVA, 13 kV, three phase 60 Hz, 8 poles and has the following parameters

   Xd=1, Xq=0.6, Xd’=0.2, Ra=0 pu

   Find Ea needed when the generator delivers 0.5 PU power at unity power factor to an infinite bus whose voltage is 1 pu. What physically controllable current does Ea relate to?

3. Look at my Mathcad implementation of Induction motor simulation in 0dq domain I Its pretty messy!)

   The mechanical equation is $J\, d\omega/dt = T - B\,\omega - Tm$ where Tm is the mechanical load torque, T is the motor torque and B represent friction or a load that is proportional to speed. I set B and Tm to zero to simulate free acceleration and the motor settles at synchronous speed.

   Modify the implementation to model motor startup against a compressor with B=0 and $Tm = K\,\omega^2$; Assume K = 0.0002.

   a. Plot phase ‘a’ stator current, phase ‘a’ rotor current and motor speed
   b. What is the final frequency of rotor current? Is the result correct?
   c. Verify the final speed using the steady state phasor model.