EEL797 Power System Dynamics
Major Exam

Maximum marks: 40 marks — Maximum time: 2 hours

Please answer all the parts of a question together. For multiple choice questions, the most appropriate answer is the correct answer.

1. Which of the assumptions in the classical model of synchronous machines used in stability studies, given below, are *incorrect*? 2
   a. The mechanical power input to each machine is constant.
   b. Synchronous machines are represented electrically by constant voltage behind transient reactance.
   c. The motion of each synchronous machine rotor is at a fixed angle relative to the angle of the voltage behind the transient reactance.
   d. Loads are represented as ZIP models, i.e. combination of constant power, constant impedance and constant current.

2. Explain the role of the washout block in a power system stabilizer. 2

3. For an unregulated classical machine, draw the block diagram ignoring the armature reaction, speed governor and other auxiliary control devices. 3

4. Consider a generator operating at steady state with a mechanical power input of P_{Mo}. Due to sudden increase in steam input, oscillations are produced. Draw the equal area criterion for this situation indicating the accelerating and decelerating areas clearly. 3

5. Consider a synchronous machine with stator windings short circuited. With a step change in the field applied voltage, $v_F = V_F\, u(t)$, write the expression for λ_D and λ_F. 2+2

6. Draw all the six windings of a synchronous machine, indicating all the relevant inductances. 3

7. A synchronous machine in the steady state is delivering power to an infinite bus. 3+9+3

$$\theta(t) = \omega_0 t + \pi/2 + \delta, \quad \delta = \pi/4$$

$$\lambda_q = \lambda_d = 1/\sqrt{2}\omega_0, \quad i_q = i_d = 1/\sqrt{2}$$

$$r = 0, \quad x_d = \omega_0 L_d = 1, \quad \omega_0 k M_F = 1, \quad T'_{do} = 1s$$

   a. Find the torque, T_E.
   b. Find $v_a(t)$, $i_a(t)$ and i_F.

c. At $t = 0$, the generator is suddenly disconnected from the infinite bus. Assuming v_F = constant, and ignoring damper windings, sketch $i_F(t)$. *Hint:* To find $i_F(0^+)$, consider the consequences of the fact that $\lambda_d(0^+) = \lambda_d(0^-)$.

8. A single machine is connected to an infinite bus via a double circuit line. At 0.1s, a fault occurs on one of the parallel lines. At 0.2s, two alternative ways of clearing the fault are presented. In one case, the faulted double circuit line is tripped (Case A), while in the other case (B), the fault is cleared with no change in topology. 2+6

   e. Indicate on the rotor angle plots, which swing curve corresponds to which case.

   f. For both cases, sketch approximately the kinetic energy, potential energy and the total energy of the fault in the respective plots below