Birla Institute of Technology & Science

Ist Semester- 2016-17

EEE F211 Electrical Machine

1. A three phase, star connected turbo alternator (turbo alternator: an alternator, or generator, that is driven by a high turbine, such as a steam turbine-clearly such as alternator will have a small number of poles P. We also have hydro alternators, which are low speed alternators.) with a synchronous per-phase reactance of 8 ohm, delivers 200A at unity power factor when connected to 11 kV constant frequency bus bars. The armature resistance for the machine is negligible.
    a. If the throttle of the turbine is held constant (amounting to maintaining the steam, or gas supply constant, that is active constant power at the shaft) while the excitation is increased by 30%, determine the new current and power factor.
    [321.4A, 0.622]
    b. The excitation emf is now held constant at the new value, and the steam supply to the turbine is gradually increased, thereby increasing the active power at the shaft. Find the value of output power at which the generator will break from synchronism, and the operating power factor under these conditions.
    [20.27MW, 0.8 lead]

2. A 6.6 kV, 50Hz star connected 3 phase synchronous generator, having a per-phase synchronous reactance of 9.5 ohm, operates on 6.6kV infinite bus bars(infinite bus bars: supply point with practically constant voltage and frequency level) with the field current set to produce excitation emf of 1.1 pu (pu: per unit. The per-unit value of any quantity states it as a multiple of the rated value. Thus 1.1 pu emf = 1.1 x 6.6 kV emf). Calculate the maximum power that this generator can feed to the bus bars, and the power factor at which it will do so.
[5.04MW, 0.74]

3. An over excited (machine excited with a field current higher than what is required for unity power factor operation; the converse is under excited operation), 50Hz star connected synchronous motor, with a synchronous reactance of 100 ohm per phase and negligible resistance, is to be used to improve the overall power factor at the supply bus of a factory to unity, while simultaneously delivering power to a 50 hp constant speed mechanical load. The remaining load of the factory connected to the supply bus (6.6kV, 50Hz, three phase) is 100kVA at a lagging power factor of 0.6. Determine the minimum VA rating, operating power factor, and excitation emf of the motor under these conditions, if its efficiency can be assumed to be 0.8.
[92.6kVA, 0.5 lead, 5434V]

4. For a 3 phase alternator rated for 230V operation, the per phase resistance and synchronous reactance are 0.152 ohm and 9.33 ohm, respectively. Find the excitation emf, the load angle, and the voltage regulation for the alternator when delivering
   a. 9.5 A at unity power factor. [278.6V, 33.43^{o},21.13%]
   b. 8.86 A at 83.3% lagging power factor. [332.7V, 20.76^{o}, 44.67%]
   c. 9.05 A at 76.41% leading power factor. [178.1V, 39.48^{o}, -22.5%]

5. A 3 phase synchronous machine, when driven at its rated speed, has an open circuit characteristic given by the following data:

Excitation Current(A)	5	10	15	20	25
Line voltage(V)	370	655	830	950	1050

   An excitation current of 10A produces a short circuit current of 200A in the armature phases. What will be the power angle of this machine when operating as a synchronous motor on 800V mains, developing 75kW, the exciting current being 20A ?
   [7.77^{o}]

6. Two similar, 6.6kV three phase alternators are operated on infinite bus bars. Each machine has a per-phase resistance of 0.05 ohm and reactance of 0.5 ohm, and supply one half of 10MW load at 80% lagging power factor initially at equal excitation. If the excitations are changed so that one generator has an armature current of 438 A, what will be the armature current of the other generator? What are the two generator excitation emf values before and after the change?
   [767 A; 6.93kV changed to 6.67kV and 7.19kV]