BITS, Pilani – Dubai
International Academic City – Dubai
IV year EEE, IInd. Semester 2009-10
Course Title - Advanced Power Systems (EEE C 462)
Comprehensive Examination
Full Marks – 80 (Weightage 40 %) Duration—3 hours
Date: 20-05-2010
Notes: Highlight all your answers by enclosing in boxes

---

(1) A three phase overhead transmission line (star connected system) has resistance and reactance of 4.5 and 22.0 ohm(per phase), respectively. The total load at the receiving end is 25.2 MW at 0.82 power factor(lagging) . The load current is 537.68 amps. The power factor angle is defined with respect to the receiving end voltage.

(a) Calculate the sending end voltage (line value)

(b) A three phase capacitor bank of 0.3 KA/phase current rating has been connected at the load (receiving) end. Will this capacitor bank be sufficient to maintain a zero voltage regulation at the same receiving end voltage? If not, calculate the MVAR rating of the additional capacitor to be connected. Derive the necessary equation ,from fundamentals, in context to zero voltage regulation, with necessary phasor diagram. [2+ 2+2+6 Marks]

2(a) Explain the operation of a Hydroelectric Power Station with relevant diagrams .
(b) The power available from a Hydro-plant is 50 MW and the discharge is 600 m^3/sec. Calculate the available head . [9+3 Marks]

3.) A three phase star connected Synchronous Generator has positive, negative and zero sequence impedances as j00.09 p.u, j0.075 p.u and j0.11 p.u , respectively. The neutral is solidly grounded. A double- line-to ground fault occurs on terminals of the generator(phase "b" and phase "c" windings shorted within themselves and connected to ground, with $Z^f = 0$). Assume $E_a = 1.0 + j0.0$ and $I_a = 0$
Calculate: (a) Calculate the magnitude of the voltage of the healthy phase (in p.u)
(b)Magnitude of the zero sequence component of the current through that phase (in p.u)
.[6+4 Marks]

4.) A three phase synchronous generator of reactance 1.2 p.u is connected to an infinite bus-bar(magnitude of voltage,V = 1.0 p.u) through transformers and a line of total reactance of 0.6 p.u. The generator excitation e.m.f is 1.2 p.u and its inertia constant is H= 3.5 MW-s/MVA. The damping power coefficient of the machine is 0.2 p.u/electrical radian/sec. The operating load angle (δ_o) = 25 degree(electrical). The prime mover (mechanical) power input to the generator remains unchanged. In connection with the Steady State Stability Criterion: (Assume, operating frequency = 50 Hz.)
(i) Develop the Differential Equation in $\Delta\delta$ (Small Perturbation Model).
(ii) Applying Laplace Transform(initial conditions being relaxed) to the D.E in (i), develop the Characteristic Equation and find out the roots.
(iii) Hence, comment on the steady state stability aspect of the machine.[2+6+2 Marks]

P.T.O.

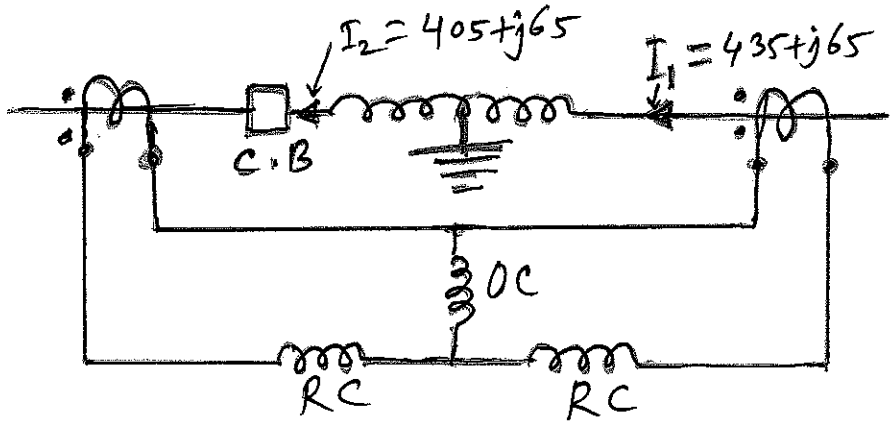
5.) A synchronous generator delivers 1.0 p.u power to an infinite bus through a transmission circuit in which resistance is neglected. The values of the maximum power transferable are given as follows:
Before fault----1.8 p.u., During fault---0.5 p.u, After clearance of the fault---1.45 p.u.
Applying equal area crieterion, determine the critical clearing angle, with proper diagrams. [10 Marks]

6.) Explain the principles of operation of "Level Detectors" and "Time Delay Units"(as components of solid state relay) with necessary circuit diagrams / equations.[7+4 marks]

7.) (a) Derive the expression for Transient Recovery Voltage [$e_{TRV}(t)$] of a circuit breaker, starting from fundamentals with completely labeled necessary circuit diagrams. Apply the method of Laplace Transform ,with all initial conditions relaxed.

(b) In context to part (a) question: L= 9.0 Henry , C= 0.02 μF and maximum value of RRRV is 800000 KV/sec
Calculate: (i) The value of E_m
(ii) Maximum value of Transient Recovery Voltage [$e_{TRV}(t)$] [6+2+2 Marks]

8.) The following figure shows the connections of a percentage differential relay to protect one phase of a generator. The relay has N_r/N_o =0.1 . A high resistance fault occurs with the current distribution shown in the figure. Will the relay operate under such conditions?----Justify your answer by showing detailed calculations. [5 marks]



BITS, Pilani – Dubai
International Academic City – Dubai
IV year EEE, 2nd Semester 2009-10
Course Title - Advanced Power Systems (EEE C 462)
Test 2(OPEN BOOK)
Full Marks – 20 (Weight age 20 %) Duration—50 min
Date: 11-04-2010
Instruction: Only text book and handwritten class notes are allowed.

1.)Two 25 MVA, 11.0 KV, three phase Synchronous Generators are connected to a common bus-bar supplying a transmission line(feeder). The star point of one generator is solidly grounded and that of the other generator is isolated.

Two three-phase transformers are installed, one being at starting position of the feeder and another one being at ending position of the feeder. The sub-transient direct axis and quadrature axis synchronous reactances ,X_d'' and X_q'', of each generator are j0.05 and j0.25 p.u ,respectively.

A "double line –to-ground" fault occurs at the load end (just after the second transformer installed at the end of the feeder). The fault occurs on phase "b" and phase "c" while it is assumed that , $I_a = 0$.

Each of the generators has positive, and zero sequence impedances as j0.2 p.u and j0.08 p.u , respectively. Each transmission line(feeder) has self reactance (X_s) of j0.5 ohm and mutual reactance of any pair of transmission lines (X_m) is j0.05 ohm. Assume that fault impedance(Z^f) is zero.

Each of the two transformers has: $Z_1 = Z_2 = Z_0 = j0.0805$ p.u

Calculate I_b (in complex rectangular/polar form and in per unit(p.u)) [9 Marks]

2) A delta connected resistive load is connected across a balanced three phase supply of 400 volts (line-to-line) as shown in the following figure (Fig. 1):

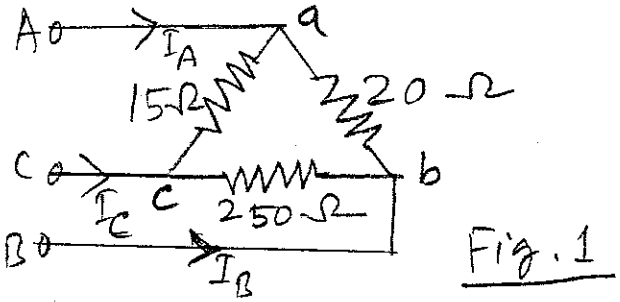


Fig. 1

Calculate the positive and negative sequence components of currents, I_{ab1} and I_{ab2} in complex polar forms. [4 Marks]

[P.T.O]

---Continued to Page 2

3)With reference to the following figure(Fig.2) , suddenly the load P_L (P_L= P_m) is put on the synchronous machine. Applying Equal Area Crietrion, prove that $\text{Sin}(\delta_c/2)=1/[1+(\pi-\delta_c)^2]^{0.5}$. Assume that $P_e= P_{max}\,\text{Sin}\delta$. [7 Marks]

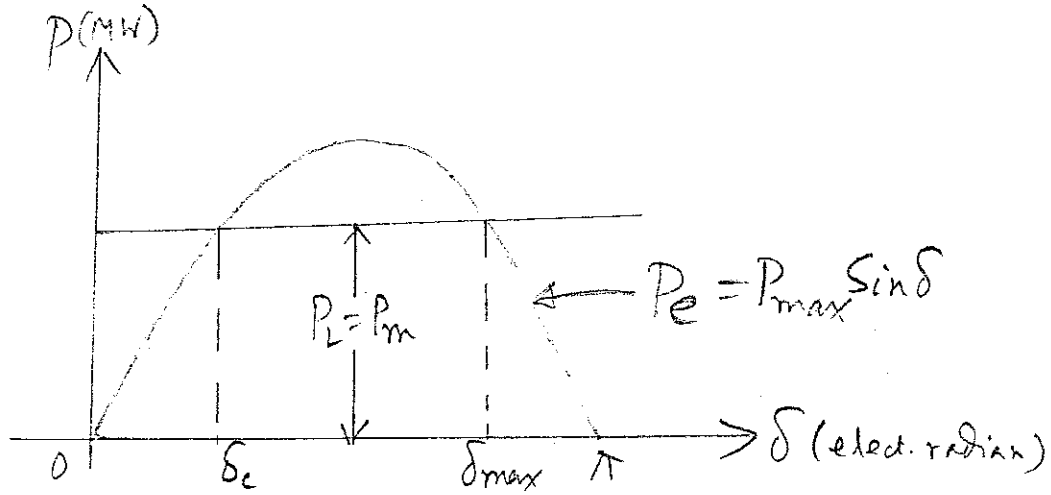


Fig. 2

---*---*---

BITS, Pilani – Dubai
International Academic City – Dubai
IV year EEE, II Semester 2009-10
Course Title - Advanced Power Systems (EEE C 462)
Test 1
Full Marks – 25 (Weightage 25 %) Duration—50 min
Date: 28---02--2010

(1) Starting from fundamentals , derive the expressions (using Laplace Transform technique) for V_x and I_x in a long transmission line(with relevant diagram), as functions of "x" and based on these expressions, prove : A= Cosh γl and B= Z_c Sinh γl , where, l= length of the line .
[6+3 Marks]

(2) A three phase 50 Hz. overhead transmission line has the generalized circuit constants: A=0.93+j0.016 and B=20+j140. The load (total, for three phases) at the receiving end is 60 MVA at 0.80 power factor (lagging) .The sending end voltage is 220 KV (line to line). Calculate the receiving-end voltage (line to line).
[7 Marks]

(3)(a) Explain the operation of a Thermal Power Station, with necessary block diagram and T-S diagram (in brief).

(b) "Generally the TURBO-ALTERNATOR used in Thermal Power Plant has synchronous speed equal to 3000 r.p.m"---Explain the statement

(c) In TURBO-ROTOR machines of Thermal Power Plant , which type of field winding conductor is used and why?------Explain . [3+4+2 Marks]

----------#----------

BITS, Pilani – Dubai
International Academic City – Dubai
IV year EEE, II Semester 2009-10
Course Title - Advanced Power Systems (EEE C 462)
Quiz 2(Set—A)
Full Marks – 07 (Weightage 7 %) Duration—20 min.
Date: 28--04—2010

Name----- Id No.------

[Marks: Questions (1)&(5) --each 2 marks and questions (2)-(4) --each 1 mark]

(1)It is given that : $\frac{d^2\delta}{dt^2} = (\pi f/H)\, P_m$. Derive the expression for Critical Clearing Time (t_{cr}) in terms of δ_{cr} and δ_o and other parameters. The symbols have their usual meanings.. State any assumption, if needed.

(2)Write the general equation of a Relay .

(3)Draw the characteristics of IDMTL Relay for different values of T.M.S

(4) Derive the expression for PICK-UP CURRENT of the Over-current Relay.

(5) $M \frac{d^2\Delta\delta}{dt^2} + \left(\frac{\partial P_e}{\partial \delta}\Big|_{\delta=\delta_0}\right) \Delta\delta = 0$---------- For such dynamics, develop the characteristic equation and find its roots.

BITS, Pilani – Dubai
International Academic City – Dubai
IV year EEE, II Semester 2009-10
Course Title - Advanced Power Systems (EEE C 462)
Quiz 1(Set—A)
Full Marks – 16 (Weightage 8 %) Duration—20 min.
Date: 23---03—2010

Name----- Id No.------

[Marks: Questions (1)-(7) --each 1 mark and questions (8)-(10) --each 3 marks]

(1)In a medium transmission line, using nominal "T" circuit , "B" will be :
(a) Z+(YZ) (b)2 Z+(YZ) (c) Z+(YZ/2) (d) Z[1+(YZ/4)]

(2) In connection with development of sub-transient/transient reactances of a three phase salient-pole Synchronous Generator, the following theorem is used for necessary explanation :
(a) Constant torque theorem
(b) Constant flux-linkage theorem
(c) Constant voltage theorem
(d) Constant power theorem

(3)In a medium transmission line, using nominal –π circuit , "D" will be
(a) Z+(YZ) (b)2 Z+(YZ) (c) 1+(YZ/2) (d) Z[1+(YZ/4)]

(4) The negative sequence reactance of a three phase Synchronous Machine is:
(a) $j\, x_q''$ (b) $j[(x_q''+ x_d'')/3)]$ (c) $j[(x_q''+ x_d'')/4)]$ (d) $j[(x_q''+ x_d'')/2]$

(5) In connection with "Theory of three phase symmetrical components":
(a) $I_b = \alpha^2 I_{a1} + \alpha I_{a2} + I_{a0}$ (b) $I_b = \alpha I_{a1} + \alpha^2 I_{a2} + I_{a0}$
(c) $I_b = \alpha^3 I_{a1} + \alpha I_{a2} + I_{a0}$ (d) $I_b = \alpha^4 I_{a1} + \alpha I_{a2} + I_{a0}$

(6) In context to a single line-to- ground fault:
(a) $I_{a1} = E_a/(Z_1 + Z_2 + Z_0 + 2 Z^f)$ (b) $I_{a1} = E_a/(Z_1 + Z_2 + Z_0 + 3 Z^f)$
(c) $I_{a1} = E_a/(Z_1 - Z_2 + Z_0 + 2 Z^f)$ (d) $I_{a1} = E_a/(Z_1 + Z_2 + Z_0 + Z^f)$

(7) For a transmission line, "$Z_1 + Z_2 + Z_0$" will be equal to :
(a) $j3\, X_s$ (b) $j3\, X_m$ (c) $j2\, X_s$ (d) $j2\, X_m$

(8) A medium transmission line has: A=D= 1+(YZ/2) and B=Z. Using a suitable property of the model , derive the expression for "C".

[P.T.O]

(9)Starting from fundamentals, prove that $[Z_S]= [A]^{-1} [Z_P] [A]$, where $[Z_S]$ represents the impedance matrix in symmetrical component model and $[Z_P]$ represents the impedance matrix in phase model and [A] bears its usual meaning.

(10) Draw the connection diagram of sequence network for a single line-to-ground (LG) fault .

----------#----------*----------*--------