BITS, Pilani – Dubai
International Academic City – Dubai
IV year EEE, Semester-I/ 2011-12
Course Title - Advanced Power Systems (EEE C 462)
Comprehensive Examination
Full Marks – 80 (Weightage 40 %) Duration—3 hours
Date: 12-01-2012
Notes: Highlight all your answers by enclosing in boxes

1(a) Explain the operation of a Nuclear Power Generation scheme with relevant diagrams/ chemical reaction equations .
(b) During the light load (or, no load) period, what may happen to the generators in a hydro-electric power station ?---Explain, in detail. [7+3 Marks]

(2) A three phase overhead transmission line(star connected system) has resistance and reactance of 5.0 and 20.0 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 15 MVAR (leading) rating has been connected at the load (receiving) end. Will this rating 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+4 Marks]

3.) Two 25 MVA, 11.0 KV, three phase star connected Synchronous Generators are connected in parallel . The star point of one of the generators is grounded through a resistance of 3.0 ohm/phase and that of the other is isolated. A "single line –to-ground" fault occurs on phase "a" and $I_b = I_c = 0$. Each generator has positive, and zero sequence impedances as j0.18 p.u, and j0.10 p.u , respectively. The values of subtransient direct axis and quadrature axis armature synchronous reactances of each machine are : $X_d'' = j\,0.18$ p.u and $X_q'' = j\,0.12$ p.u . Fault impedance is neglected.
Calculate: (a) Negative sequence reactance of each machine. (b) the fault current (in p.u)
(c) the current in the grounding resistor (in amps or kilo amps.) [2+ 6+2 Marks]

4(a) Analyze , how you will assure "Steady state stability" of a power system, with all necessary equations derived using small perturbation model (using " Laplace Transform") for a system with damping. Operating point must be considered in the analysis

b)With reference to Fig.1, the given data are(phase angles given in degree unit):
$V_{an} = 100\, e^{j\,0}$, $V_{bn} = 60\, e^{j\,60}$, $V_{an} = 60\, e^{j\,120}$, $jX_{ab} = jX_{bc} = jX_{ca} = j5.0$ ohms , $j\,X_s = j12.0$ ohms. Calculate I_a and I_b using the theory of Symmetrical Components. [6+6 Marks]

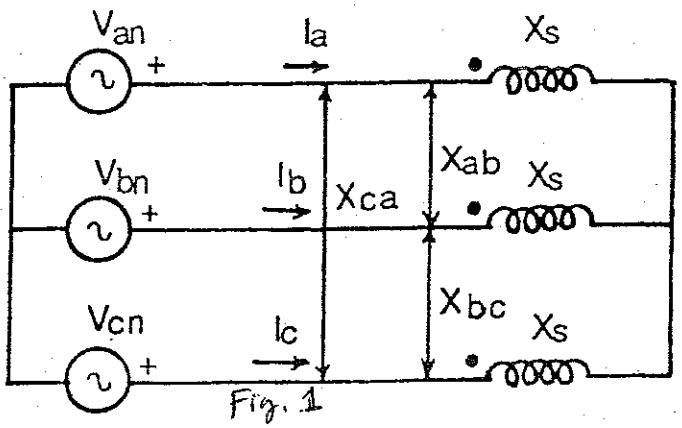

Fig. 1

[P.T.O]

5.) (a) Prove that $X_d'' = 1/[(1/X_{md})+(1/x_f)+(1/x_{kd})$, where the symbols have their usual meanings and hence draw the subtransient equivalent circuit of three phase salient pole synchronous generator (as a power system component) along direct axis. Start the analysis from fundamentals (also the small perturbation model is to be used) and draw the necessary machine models/diagrams. All figures/diagrams should be labeled.

(b) In context to "Transient Recovery Voltage [$e_{TRV}(t)$] of a circuit breaker" : L= 9.0 Henry , C= 0.02 μF and supply voltage per phase (r.m.s value) =220 KV.
Calculate: (i) Maximum value of Transient Recovery Voltage [$e_{TRV}(t)$]
(ii) Maximum value of RRRV [7+2+2 Marks]

6. (a) Explain the process of development of "ARC" in a Circuit Breaker with necessary diagrams.
(b) Draw only a neat diagram (labeled) of a SF_6 circuit breaker (no explanation) OR Vaccum Circuit Breaker(VCB) (no explanation) . What are the advantages of any one of those two circuit breaker?
[5+2+2 Marks]

7.) Explain the principles of " Differential Relay"and " Percentage Differential Relay" with necessary circuit diagrams and all mathematical equations.
[5+5 Marks]

8.) A Synchronous generator is feeding 275MW to a large50Hz network over a double circuit transmission line. The maximum steady state power that can be transmitted under different conditions, are as follows :-

Prefault ---------- 480MW
Post Fault ---------- 325MW

A solid three phase symmetrical fault occurring at the network-end of one of the lines causes it to trip. Estimate the critical clearing angle in which the circuit breakers must trip so that synchronism is not lost. Consider that the maximum load angle (δmax) is the angle at the point of intersection by the 275 MW line with the post-fault P- δ curve. Apply the "Equal Area Criterion" method. [8Marks]

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BITS, Pilani – Dubai
Dubai International Academic City
IV year EEE, 1st Semester 2011-12
Course Title - Advanced Power Systems (EEE C 462)
Test 2(OPEN BOOK)
Full Marks – 20 (Weightage 20 %) Duration—50 min
Date: 22-12--2011

Instructions: Only text book and handwritten class notes are allowed.

1.)One 25 MVA, 11.0 KV,three phase Synchronous Generator is connected to a bus-bar supplying a transmission line. The star point of the generator is grounded through a resistance of 1.0 ohm/phase. A "double line –to-ground" fault occurs at the far end of the transmission line. The fault occurs on phase "b" and phase "c" while it is assumed that , $I_a = 0$. The generator has positive, negative and zero sequence impedances as j0.2 p.u, j0.15 p.u and j0.08 p.u , respectively. Each transmission line has self reactance (X_s) of j0.6 ohm and mutual reactance of any pair of transmission lines (X_m) is j0.2 ohm. Assume that fault impedance(Z^f) is zero.
Calculate I_{a1}, I_{a2} and I_{a0} . 8 Marks

2)A Synchronous generator is feeding 250MW to a large 50Hz network over a double Circuit transmission line. The maximum steady state power that can be transmitted under different conditions, are as follows :-

Prefault ---------- 500MW

During Fault--------175 MW

Post Fault ---------- 350MW

Estimate the critical clearing angle in which the circuit breakers must trip so that synchronism is not lost. Consider that the maximum load angle (δmax) is the angle at the point of intersection by the 250MW line with the post-fault P- δ curve. Apply the "Equal Area Criterion" method. 6 Marks

3)With reference to the following figure(Fig.1) , suddenly the load P_L ($P_L = P_m$) is put on the synchronous machine. Applying Equal Area Crietrion, prove that $\sin(\delta_c/2) = 1/[1+(\pi-\delta_c)^2]^{0.5}$. Assume that $P_e = P_{max} \sin\delta$. [6 Marks]

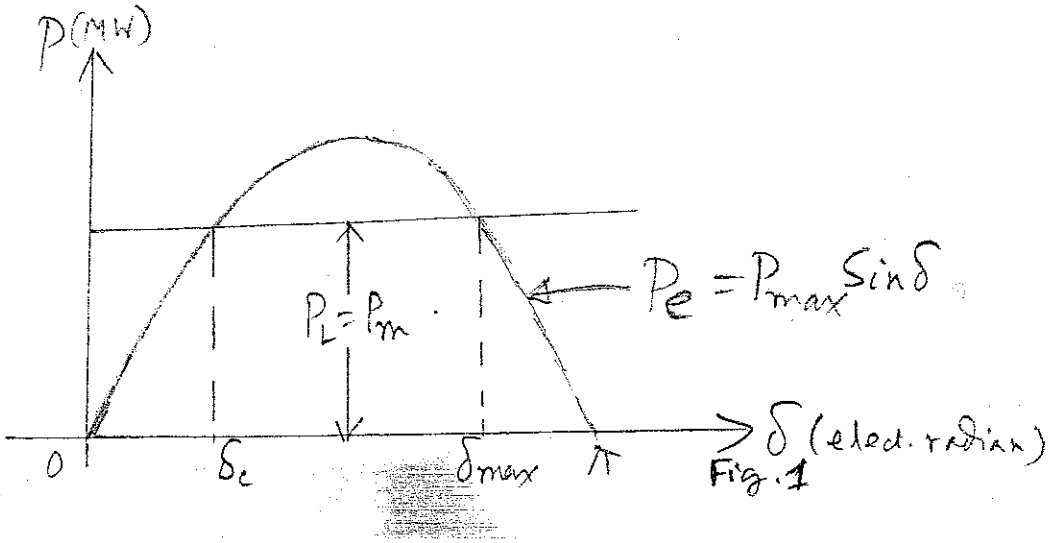

Fig.1

BITS, Pilani – Dubai
International Academic City – Dubai
IV year EEE, I Semester 2011-12
Course Title - Advanced Power Systems (EEE C 462)
Test 1
Full Marks – 25 (Weightage 25 %) Duration—50 min
Date: 03---11—2011

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(1) A short transmission line with a reactance of 18.0 ohm per phase(resistance of the line being considered as zero) supplies a load at0.85 power factor(lag). For a transmission line current of 1100 Amps. per phase, the receiving- and sending-end voltages are to be maintained at 230KV(line-to-line) . Calculate the required MVAR rating of synchronous capacitor to be installed . Active power drawn by the synchronous capacitor may be neglected.
The necessary expression (formula) for zero voltage regulation may be directly used and the necessary circuit diagram must be drawn. [7 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 magnitude of receiving-end voltage (line to line). [10Marks]

(3)(a) Only draw a neat diagram of a "Nuclear Power Generation Scheme" with detailed labeling-----No explanation.
(b) Starting from fundamentals, develop the Subtransient Equivalent Circuit (along the quadrature axis) of a three phase salient pole synchronous generator as a power system component, along with all other necessary diagrams and hence derive the expression for X_q''.---------- [3+5 Marks]

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BITS, Pilani – Dubai
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IV year EEE, 1st Semester 2011-12
Course Title - Advanced Power Systems (EEE C 462)
Full Marks – 07 (Weightage 7 %) Duration—20 min./Quiz 2

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

[Marks: Questions (1)&(2) --each 2 marks and rest questions --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) $M\frac{d^2\Delta\delta}{dt^2} + \left(\frac{\partial Pe}{\partial\delta}\right)_{\delta=\delta_o}\Delta\delta = 0$---------- For such dynamics, develop the characteristic equation and find its roots.

(3)Draw the connection diagram (labeled) of sequence networks for a double line-to-ground (LLG) fault .

(4) Zero sequence network is not involved in the case of : (Choose the correct answer): (a) Double line- to-ground fault (b) Line-to-line fault (c) Single line-to-ground fault

(5) For a Single line-to-ground fault, at the fault point "F", the currents and voltages are constrained as: (Fill in the blanks): I_b =----------, I_c =----------, V_a =----------

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IV year EEE, 1st Semester 2011-12

Course Title - Advanced Power Systems (EEE C 462)
Quiz 1
Full Marks – 08 (Weight age 8 %) Duration—20 min.
Date: 03-10-2011

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

Marks distribution: Questions (3)and (6)---2 Marks each and rest – 1 mark each

(1)The expression ,A= Cos hγl is valid for: (a) Short line (b) Long line (c) Medium line

(2) A medium transmission line has A=D=1+(YZ/2). The representation will be:
(a) Nominal T-ciruit (b) Nominal π-ciruit (c) Either of (a) or (b) (d) None of them

(3) In a long transmission line, B=131.2 $e^{j72.3}$ and C= j0.001, where the phase angle has been given in degree unit. Calculate Z_C (=Characteristic Impedance) in Complex Rectangular or Complex Polar form.

(4) In a short transmission line, " Zero Voltage Regulation" is to be achieved by installing a three phase Synchronous Motor . Is it feasible at all? If yes , how?---Explain .

(5) At which stage is Superheated Steam used (in context to Thermal Power Plant)?---------- and Why?-----Answer with reasoning.

(6) Prove, in a long transmission line that AD-BC=1.