BITS, Pilani – Dubai
International Academic City – Dubai
IV year EEE, 2nd Semester 2010-11

Course Title - Advanced Power Systems (EEE C 462)
Comprehensive Examination
Full Marks – 80 (Weight age 40 %) Duration—3 hours
Date: 07-06-2011

1(a) Explain the operation of a Hydroelectric Power Station with necessary diagrams.
(b) Write the merits and demerits of a Nuclear Power Station. [8+2 Marks]

2. A 50 Hz. Transmission line has a total series impedance of 40+j125 ohms and a total shunt admittance of 0.001 mho. The receiving end load is 47.0 MW at 220 kV(line voltage) with 0.75 power factor(lagging).Calculate the sending end voltage and sending end current using: (i) Nominal T-representation and(ii) Using approximate equations: A=D =1+(YZ/2) , B=Z[1+(YZ/6)] , C=Y[1+(YZ/6)] [5+5 Marks]

3.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 ---------- 510MW
Post Fault ---------- 360MW

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. [8 Marks]

4(a) Starting from fundamentals, develop the "Swing Equation" of a synchronous machine as a power system component. Each step of the analysis should be presented.

(b)Based on the "Swing Equation" of question 4(a) , derive the mathematical expression for "Equal Area Criterion". [8+4 Marks]

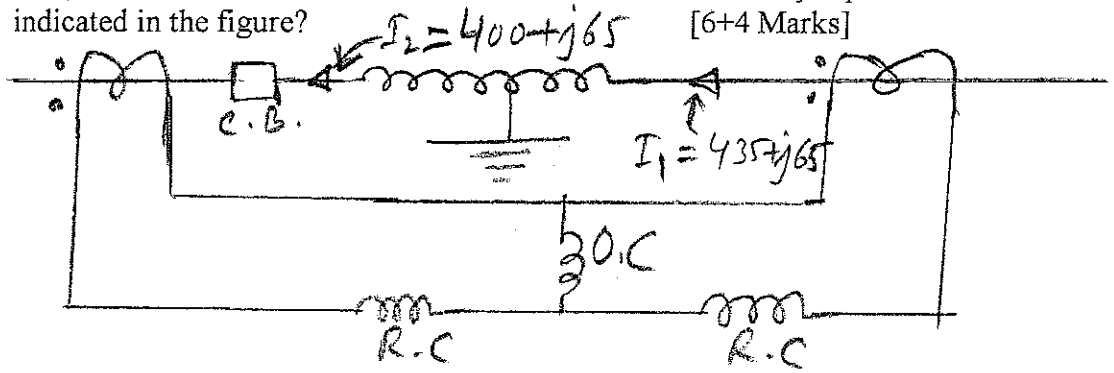
5. A three phase star connected synchronous generator has positive, negative and zero sequence reactance of each being j0.08, j0.07 and j0.1 p.u. The neutral is solidly grounded. A double line- to –ground fault occurs on terminal of the generator(phase "b" and phase "c" windings shorted within themselves and connected to ground ,with Z^f =0.2+j0 p.u.).Calculate the voltage of the healthy phase and negative sequence component of the current through that phase. Assume that E_a =1+j0 and I_a =0. . [10 Marks]

6. Explain the operation of a Vacuum Circuit Breaker(VCB) with necessary diagrams. [8 Marks]

[P. T. O]

7(a) Derive the equation of locus (in R-X plane)of a Modified Impedance Relay, with all necessary diagrams.

(b) The following figure shows the connections of a percentage differential relay to protect one phase of a generator. The relay has $N_r / N_o = 0.05$. A high resistance fault occurs with the current distribution shown. Will the relay operate under conditions indicated in the figure? [6+4 Marks]



8(a) Explain the concept of "Constant Flux Linkage Theorem" and develop the q-axis sub-transient equivalent circuit of salient pole synchronous generator as a component of power system after deriving all flux linkage equations in detail along with all other necessary diagrams.

(b) Starting from fundamentals, derive the expression for fault current in the case of a line-to-line fault. Draw the necessary diagrams. [6+6 Marks]

BITS, Pilani – Dubai
International Academic City – Dubai
IV year EEE, 2nd Semester 2010-11
Course Title - Advanced Power Systems (EEE C 462)
Test-II (Open Book)
Full Marks – 20 (Weightage 20 %) Duration—50 min.
Date: 24-04-2011
Instruction: Text Book and handwritten class notes are only allowed.

1.) Two 20 MVA, 11.0 KV (line-to-line), three phase star connected Synchronous Generators are connected in parallel . The star point of one of the generators is grounded through a resistance of 2.5 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, negative and zero sequence impedances as j0.18 p.u, j0.15 and j0.10 p.u , respectively. Fault impedance is neglected.
Calculate:
(a)the fault current (in p.u), in complex polar form.
(b) the current(magnitude) in the grounding resistor (in amps) [4+3 Marks]

2.) A three phase salient-pole synchronous generator having direct and quadrature axes steady state synchronous reactances (X_d and X_q) of 0.75 p.u and 0.55 p.u, respectively is connected to an infinite bus-bar(magnitude of voltage, V = 1.0 p.u) through transformers and a line of total reactance of 0.5 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) = 20 degree(electrical). The prime mover (mechanical) power input to the generator remains unchanged. The total amount of transformer and line reactance is to be considered in series with X_d for all types of calculations needed. The system frequency is 50 Hz. All reactances are given in per phase .
In connection with the Steady State Stability Criterion:
(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+3+1 Marks]

3.) A synchronous generator delivers power to the power system as shown in Fig. 1. The mechanical input to the synchronous generator has been suddenly increased from 0.3 to 0.7 p.u(as shown in Fig.2) . Using Equal Area Crieterion, prove that $1.92\cos(\delta_2) + 0.7$ $(\delta_2) = 2.00$ [7 Marks]

[P.T.O]

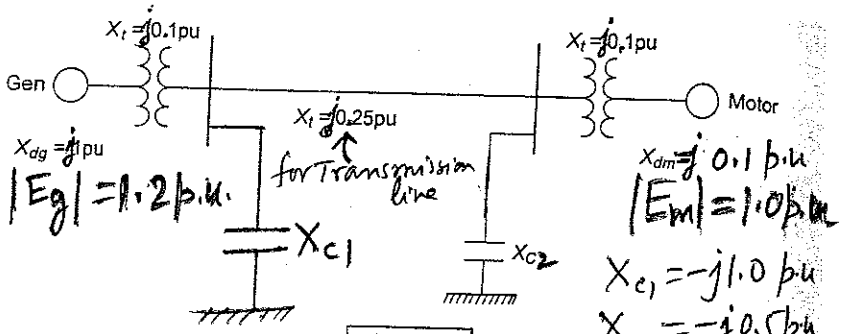

$X_t = j0.1$pu
Gen
$X_t = j0.25$pu
for Transmission line
$X_t = j0.1$pu
Motor
$X_{dg} = j1$pu
$|E_g| = 1.2$ p.u.
X_{c1}
X_{c2}
$X_{dm} = j0.1$ p.u
$|E_m| = 1.0$ p.u
$X_{c1} = -j1.0$ p.u
$X_{c2} = -j0.5$ p.u

Fig. 1

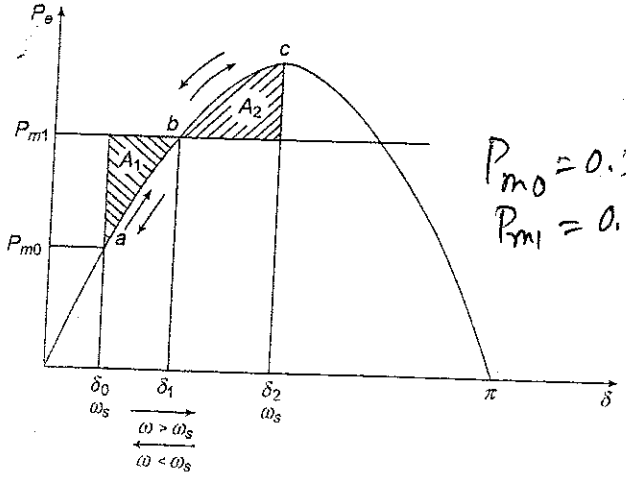

P_e
P_{m1}
P_{m0}
a
b
c
A_1
A_2
δ_0
ω_s
δ_1
$\omega > \omega_s$
$\omega < \omega_s$
δ_2
ω_s
π
δ
$P_{m0} = 0.3$ p.u
$P_{m1} = 0.7$ p.u.

Fig. 2

BITS, Pilani – Dubai
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IV year EEE, 2nd Semester 2010-11
Course Title - Advanced Power Systems (EEE C 462)
Test 1
Full Marks – 25 (Weightage 25 %) Duration—50 min
Date: 06---03--2011

1) A transmission line has A=D =$0.9e^{j1.5}$ and B =$150e^{j65}$ .The line has, at the load end, an equipment as load having a nominal π-representation of its equivalent circuit as follows: Total series impedance of the load =Z = 127.4 $e^{j74.2}$ ohm and total shunt admittance of the same equipment =Y= 0.000845 e^{j90} mho .

The load end voltage and current are V_L and I_L ,respectively. All phase angles are given in degree unit.

(a)Derive the expressions for A_1, B_1 ,C_1, D_1 where it is given that: $V_S = A_1 V_L + B_1 I_L$ and $I_S = C_1 V_L + D_1 I_L$.

(b) In context to part (a), calculate the numerical value of A_1 (either in polar or rectangular,complex form) . [6+3 Marks]

(2)A three phase 50 Hz. overhead transmission line has Z=40+j125 ohms (per phase) and Y=j 0.001 mho(per phase), respectively. The load (total, for three phases) at the receiving end is 45 MW at 0.85 power factor(lagging) and at voltage of 220KV(L-L).

Calculate the sending end voltage magnitude (per phase value, in Kilo-Volts),using A=Cos hγl and B=Zc Sin hγl

[7 Marks]

(3) Explain the salient points of a Thermal Power Station with block diagram and T-S diagram (with labeling) --------- [5+2+2 Marks]

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BITS, Pilani – Dubai **[Set—A]**
International Academic City – Dubai
IV year EEE, II Semester 2010-11
Course Title - Advanced Power Systems (EEE C 462)
Quiz 2(Set—A)
Maximum Marks – 14 (Weightage 7 %) Duration—20 min.
Date: 09--05—2011

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

[Marks: Questions (1)to(6) --each 2 marks and questions (7)|&(8) --each 1 mark]

(1)Write the general relay equation, defining all the terms.

(2) Derive the expression for "Pick Up Current"of the Over-current Relay.

(3) Draw the circuit diagram of a Modified Impedance Relay with proper labeling.

(4) Draw the circuit diagram of a Differential Relay for protection of a Generator phase winding , with proper labeling.

[P.T.O]

(5) Draw typical characteristics for IDMTL relays for two values of TMS, with necessary labeling.

(6) Why is "τ" made 90 degree in the case of a Reactance Relay ?---Explain

(7)$(R-R_s)^2 + (X-X_s)^2 = |Z_{rs}|^2$----This equation refers to:
(a) Differential relay (b) Reactance relay (c) Over current relay (d) Modified Impedance relay.

(8) " It is not necessary that Relaying equipment must clearly discriminate between normal and abnormal system conditions"----TRUE and FALSE ?

BITS, Pilani – Dubai
International Academic City – Dubai
IV year EEE, 2nd Semester 2010-11

Course Title - Advanced Power Systems (EEE C 462)----- Set--A

Quiz 1 / Date—28/3/2011/ F. M – 16 (Weightage 8 %) / Duration—20 min

Set--A

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

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(1) 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) $j[(x_q''+x_d'')/2]$-------[1 M]

(2) 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) $I_b = \alpha^4 I_{a1} + \alpha I_{a2} + I_{a0}$ -------[1 M]

(3) 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) $j2\,X_m$ -------[1 M]

(4) For a three phase delta connected load, the line currents are I_A, I_B and I_C. $I_A = 10e^{j30}$, $I_B = 15e^{-j60}$. Calculate the negative sequence current component (I_{A2}) -------[3 Marks]

(5) Write the flux-linkage equations (small perturbation model) of two coils /windings placed on the quadrature axis of the Primitive machine model of a three phase salient pole synchronous machine in terms of per unit quantities with the relevant diagram. -------[3 Marks]

P.T.O

SET-A

(6) For a Synchronous Machine, zero sequence impedance (Z_0) must be:
(a)$Z_0 = 2\ Z_n + Z_{0g}$ (b) $Z_0 = (1/2)\ Z_n + Z_{0g}$ (c) $Z_0 = 3\ Z_n + Z_{0g}$ -------[1 M]

(7) Which is correct?--- (a) $\alpha^2 + \alpha^4 = 0$ (b) $\alpha^2 + \alpha^4 = 1$ (c) $\alpha^2 + \alpha^4 + 1 = 0$ (d) $\alpha^2 + \alpha^4 = 2$ -------[1 M]

(8) Draw the negative sequence network of a synchronous machine (with labeling) -------[2 Marks]

(9) "Third harmonic component current is equivalent to negative sequence component current"----Statement----- TRUE or FALSE ? -------[1 M]

(10) Write the expression for complex power in a three phase system in terms of phase voltage and currents (either in Matrix equation form or in algebraic equation form) and hence find the expression for the same complex power in terms of Symmetrical(or, sequence) components and associated terms. ----[2Marks]