BITS, Pilani – Dubai
International Academic City – Dubai
IV year EEE, IInd. Semester 2008-09

Course Title - Advanced Power Systems (EEE C 462)
Comprehensive Examination
Full Marks – 80 (Weightage 40 %) Duration—3 hours
Date: 24-05-2009
Notes: Highlight all your answers by enclosing in boxes

1(a) Explain the operation of a Thermal Power Station with relevant T-S diagram and other diagrams.
(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) Explain the concept of "Steady state stability" of a power system, with all necessary equations derived (using " Laplace Transform" or, otherwise).
(b) What will be the frequency of oscillation if sustained oscillation is assumed in context to steady state stability?

[P.T.O]

(c) What are the differences between "Steady state stability" and "Transient stability" of a power system?---Write any two points.
[6+2+2 Marks]

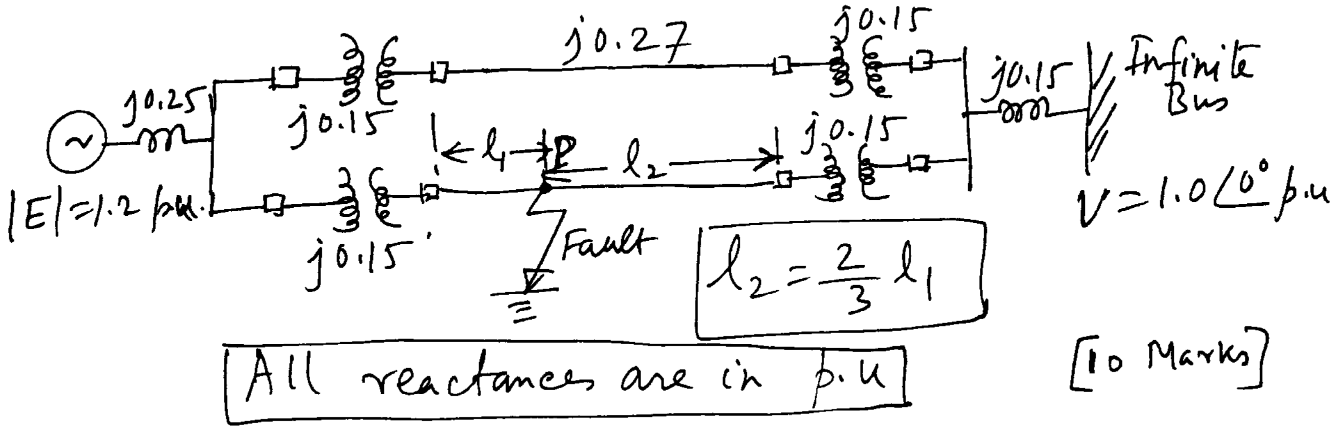
5.) (a) Derive the expression for Transient Recovery Voltage [$e_{TRV}(t)$] of a circuit breaker, starting from fundamentals with completely labeled necessary circuit diagrams. Apply the method of Laplace Transform ,with all initial conditions relaxed.

(b) In context to part (a) question: L= 9.0 Henry , C= 0.02 μF and 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 [6+2+2 Marks]

6. (a) Explain the process of development of "ARC" in a Circuit Breaker with necessary diagrams.
(b) Draw a neat diagram (labeled) of a SF_6 circuit breaker (no explanation) . What are the advantages of this circuit breaker?
[5+2+3 Marks]

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

8.) Applying "Equal Area Criterion" , calculate the critical clearing angle for the system shown in the following figure for a three –phase fault at the point "P". The generator is delivering 1.0 p.u power under pre- fault condition. Total reactance for (l_1 + l_2) length of the second line is j0.27 . At the post-fault condition, the faulty line is switched off and power is supplied through the healthy line(line no. 1). All reactances are given in p.u.



[10 Marks]

BITS, Pilani – Dubai
International Academic City – Dubai
IV year EEE, 2nd Semester 2008-09
Course Title - Advanced Power Systems (EEE C 462)
Test 2(OPEN BOOK)
Full Marks – 20 (Weight age 20 %) Duration—50 min
Date: 19-04-2009

INSTRUCTION :–
(Text Book and Handwritten class Notes only 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

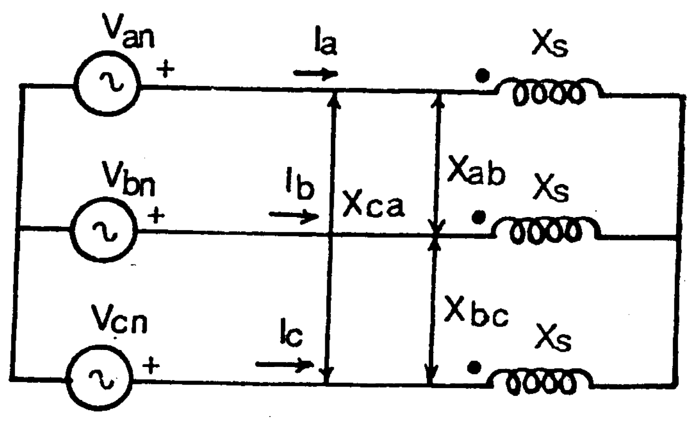
2.)A Synchronous generator is feeding 275MW to a large 50Hz. network over a double circuit transmission line. The maximum steady state power that can be transmitted under different conditions, are as follows :-

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

A solid three phase symmetrical fault occurring at the generator-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. [6 Marks]

3.)With reference to the following figure, the given data are:

$V_{an} = 100\, e^{j\,0}$,$V_{bn} = 60\, e^{j\,60}$,$V_{cn} = 60\, e^{j\,120}$, $jX_{ab} = jX_{bc} = jX_{ca} = j5.0$ ohms , j X_s =j12.0 ohms. Calculate I_a and I_b using the theory of Symmetrical Components. The phase angles are given in degree units. [6 Marks]



BITS, Pilani – Dubai
International Academic City – Dubai
IV year EEE, 2nd Semester 2008-09

Course Title - Advanced Power Systems (EEE C 462)
Test 1
Full Marks – 25 (Weight age 25 %) Duration—50 min
Date: 09-03-2009

1) A transmission line has A=D $=0.9e^{j1.5}$ and B $=150e^{j65}$ .The line has, at the load end, a transformer having a nominal T-representation of its equivalent circuit as follows: Total series impedance of the transformer $=Z_T = 101.2\ e^{j74.2}$ ohm and total shunt admittance of the same transformer =Y= 0.000738 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 values of A_1 and C_1(either in polar or rectangular,complex form) . [6+3 Marks]

(2) A three phase overhead transmission line has resistance and reactance of 5.0 and 20.0 ohm(per phase), respectively. The load at the receiving end is 25.2 MW at 0.82 power factor(lagging) and at voltage of 33KV(L-L).

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

(b)Calculate the KVAR rating (or,MVAR rating) of the compensating equipment inserted at the receiving end so as to maintain a zero voltage regulation at the same receiving end voltage. Derive the necessary equation ,from fundamentals, in context to zero voltage regulation, with necessary phasor diagram. [2+6 Marks]

(3) (a) Explain the main features and principle of operation of a hydro-electric power station, with a neat diagram.

(b) What are the possibilities of operation of the Salient pole Synchronous Machine, during the LIGHT LOAD period of a Hydro Electric Power Station?---Explain. . [6+2 Marks]

Duration – 10 minutes | BITS, Pilani – Dubai (Set-A)

(Set-A)

IInd Semester, 2008-09

4th yr (EEE) / Advanced Power Systems (EEE C46..) — Course Title

Date – 30/04/09 Quiz-3 (F.M = 5) (Weightage – 5%)

Name – – – – – – – – – Id.No. – – – – – – – – –

(1) Neglecting saliency, power system steady state stability limit corresponds to :–
(a) $\delta = 40°$ (b) $\delta = 90°$, (c) $\delta = 75°$, (d) $\delta = 180°$ — — [1M]

(2) "A synchronous generator, having no damper winding but having some armature winding copper loss, will have a SWING EQUATION,

$$M \frac{d^2\delta}{dt^2} = P_m - P_e$$

" — Is this Statement → TRUE / FALSE? —— [1M]

(3) Which is correct? —— (a) $M = \frac{4GH}{(\pi)^2 f}$
(b) $M = \frac{2GH}{\sqrt{\pi} f}$ (c) $M = \frac{GH}{\pi f}$ — — [1M]

(4) Neglecting saliency :– (a) $P_{max} = \frac{|E||V|}{2X}$
(b) $P_{max} = \frac{|E|(|V|)^2}{4X}$ (c) $P_{max} = \frac{|E||V|}{X}$ (d) $P_{max} = \frac{(|V|)^2}{X}$ — — — [1M]

(5) The transformed equation,

$$\left[MS^2 + \left\{ \frac{\partial P_e}{\partial \delta}\Big|_{\delta=\delta_0} \right\} \right] \Delta\delta(s) = 0$$

(where, $\Delta\delta(s) = \mathcal{L}\,\Delta\delta(t)$) corresponds (relates) to :–
(a) Transient Stability (b) Steady State Stability
(c) Dynamic Stability — — — [1 Marks]

[P.T.O]

(6) Out of the following, Which Combination is Correct with ref. to Fig.(1)? :—

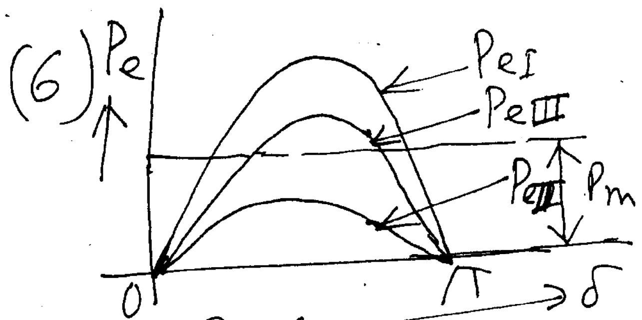


Fig (1)

(a) Pe_{II} — Prefault, Pe_{I} — Post fault, Pe_{III} — During fault

(b) Pe_{I} → Prefault, Pe_{II} → During Fault, Pe_{III} — Post fault

(c) Pe_{I} → During fault, Pe_{II} → Post Fault, Pe_{III} → Pre fault — — — [1 Mark]

(7) ~~Swing Equation~~ "Equal Area Criterion" is represented by the equation :—

(a) $\int_{\delta_{initial}}^{\delta_{final}} (P_m - P_e)^2 \, d\delta = 0$ (b) $\int_{\delta_{initial}}^{\delta_{final}} \sqrt{(P_m - P_e)} \, d\delta = 0$

(c) $\int_{\delta_{initial}}^{\delta_{final}} (P_m - P_e) \, d\delta = 0$ — — — — [1 Mark]

(8) $Q = K_1 (|I|)^2 - K_4 > 0$ represents ~~a~~ :—

(a) Impedance Relay (b) Differential Relay

(c) Over Current Relay (d) Under Frequency Relay — — — [1 Mark]

(9). "For ~~a~~ Relay, Actual current (magnitude) = 3 amp Pick-up Current = 5 amps. The Relay trips the Circuit breaker." — Statement — TRUE/FALSE? — — [1 Mark]

(10) The "$A_1 = A_2$" criterion represents a DECAYING OSCILLATION in "δ" — TRUE/FALSE? [1M]

Set-B

Set B

BITS, Pilani-Dubai

IInd Semester, 2008-09

Course Title / No. — Advanced Power Systems (EEE C462)

4th yr (EEE) QUIZ-3 (F.M= 5 (5%))

Duration – 10 mins.

Date – 30/04/09

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

Each question carries 1 Mark

(1) For a SYNCHRONOUS MACHINE, K.E = Kinetic Energy. Then :– (a) $K.E = \frac{1}{4} M \omega_s$ (b) $K.E = \frac{1}{2} M \omega_s$ (c) $K.E. = \frac{3}{4} M \omega_s$

(2) "A synchronous generator having no damper winding and having no loss (The machine is lossless) will have a SWING EQUATION, $M \frac{d^2\delta}{dt^2} = P_m - P_e$." → Statement – "TRUE/FALSE"?

(3) A Turbo generator is rated as 100 MVA. Its inertia constant = 8.0 MJ/MVA. Its stored energy in Mega Joule unit will be :–
(a) 400 (b) 800 (c) 600 (d) 1200

(4) The equation in the form, $\Delta P_e = \left(\frac{\partial P_e}{\partial \delta} \Big|_{\delta=\delta_0} \right) \Delta\delta$ will represent :– (or, indicate)
(a) Steady state Stability Problem
(b) Dynamic Stability Problem
(c) Transient Stability Problem

(5) Neglecting saliency, power system steady state stability limit corresponds to :–
(a) $\delta = 25°$ (b) $\delta = 110°$ (c) $\delta = 90°$, (d) $\delta = 145°$

(6) Equal Area Criterion, which is $A_1 = A_2$ can be represented by :– (a) $\int_{\delta_0}^{\delta_f} (P_a)^2 d\delta = 0$
(b) $\int_{\delta_0}^{\delta_f} (P_a) d\delta = 0$ (c) $\int_{\delta_0}^{\delta_f} (P_a)^3 d\delta = 0$

P.T.O.

(7) "The "$A_1 = A_2$"-criterion represents a SUSTAINED OSCILLATION in torque-angle (δ) (load angle), of the machine"

— Statement — TRUE / FALSE ?

(8) Machine no. 1 :- $|E| = |E_1|$, $|V| = |V_1|$, $X = X_1$

Machine no. 2 :- $|E| = 2|E_1|$, $|V| = \frac{|V_1|}{2}$ and $X = \frac{X_1}{4}$

Which machine will have steady State Stability limit more ? —

(9) $Q = K_3 |V| |I| \cos(\theta - \tau) > 0$ represents a

(a) Impedance Relay (b) Pilot Relay (c) Over Current Relay (d) Directional Relay

(10) Locus of an Impedance Relay in R–X plane will be :—

(a) Ellipse (b) straight line

(c) circle (d) Hyperbola

BITS, Pilani — Dubai / International Academic City, Dubai

4th yr (EEE) / IInd Sem, 2008–09

Course Title/No. – ADVANCED POWER SYSTEMS (EEE C462)

Full Marks – 10 (Weightage 5%) (SET–A)

Quiz–2 / Date – 26/03/2009

SET-A

QUIZ–2

Name ---   Id No. ---

Instructions:– Q.(1) to Q.(6) → 1 mark each and Q.(7) & Q.(8) → 2 marks each

1.) V_{a1} can be expressed as :–

(a) $V_{a1} = \frac{1}{3}(V_a + V_b + 2V_c)$ (b) $V_{a1} = \frac{1}{3}(V_a + \alpha V_b + \alpha^2 V_c)$

(c) $V_{a1} = \frac{1}{3}(2V_a + \alpha V_b + V_c)$

2.) In context to the study on Symmetrical Components, following a "symmetrical fault":–

(a) After the fault, the system variables must remain balanced

(b) After the fault, the system variables become unbalanced

(c) After the fault, the system variables may or may not be balanced

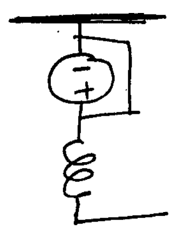
3.) If the phase sequence is A-C-B (or, phase 'a' – phase 'c' – phase 'b'), then :–

(a) $V_a = V_a$; $V_b = \frac{V_a}{2}$; $V_c = \alpha^2 V_a$

(b) $V_b = \alpha^2 V_a$; $V_a = V_a$; $V_c = \frac{V_a}{2}$

(c) $V_a = V_a$; $V_b = \alpha V_a$, $V_c = \alpha^2 V_a$

4.)



This figure corresponds to :–

(a) Positive sequence network of Synchronous machine

(b) Negative sequence network of synchronous machine

(c) Either negative sequence or zero sequence network of synchronous machine

5.) In a single line-to-ground fault :–

(a) $I_{a1} = I_{a2} = I_{a0} = \frac{1}{4} I_a$ (b) $I_{a1} = I_{a2} = I_{a0} = \frac{1}{3} I_a$

(c) $I_{a1} = I_{a2} = I_{a0} = \left(\frac{1}{\alpha}\right) I_a$

P.T.O.

(6) The condition $V_a = Z^f I_a$ corresponds to:—

(a) Line-to-Line fault
(b) Double line-to-Ground fault
(c) Single line-to-Ground fault

(7) Write merit and demerit (one for each) of Nuclear Power Station.

(8) Prove that Third harmonic components are similar to zero sequence components (mathematically).

QUIZ-2

SET-B

BITS, Pilani-Dubai / International Academic City, Dubai
4th yr (EEE) / IInd Sem., 2008-09
Course Title/No. — Advanced Power Systems (EEE C462)
Full Marks—10 (Weightage—5%) (Set-B)
QUIZ-2 / Date - 26/03/2009

Name - - - -   Id No. - -

Instruction: Question (1) to (6) → 1 mark each and Q.(7) & Q(8) → 2 Marks each

1.) V_{a2} can be expressed as :-
(a) $V_{a2} = \frac{1}{3}(V_a + 2V_b + V_c)$ (b) $V_{a2} = \frac{1}{3}(V_a - \alpha V_b - \alpha V_c)$
(c) $V_{a2} = \frac{1}{3}(V_a + \alpha^2 V_b + \alpha V_c)$

2.) Which is the correct option?:—
(a) $[V_s] = [A]^* [V_p]$ (b) $[V_s] = [A]^{-1} [V_p]$ (c) $[V_s] = \frac{1}{2}[A]^* [V_p]$

3.) Total complex power (S) in a three phase system is given by:— (for $[S] = S$):—
(a) $[S] = [I_s][V_s][A]^{-1}[A]^*$ (b) $[S] = [V_s]^T [A]^T [A] [I_s]^*$
(c) $[S] = \frac{1}{2} [V_s]^T [A]^T [A] [I_s]$

4.) Symmetrical Component Transformation is POWER INVARIANT — "True" or "False"?

5.) I_{a0} (zero sequence current component of phase-a) can be expressed as
(a) $I_{a0} = \frac{1}{3}(I_a + I_b + I_c)$ (b) $I_{a0} = \frac{1}{3}(\alpha^2 I_a + I_b + I_c)$
(c) $I_{a0} = \frac{1}{3}(2I_a + \alpha I_b + I_c)$

6.) The condition $V_b = V_c = Z^f (I_b + I_c)$ corresponds to:—
(a) Single line-to-ground fault
(b) Double line-to-ground fault
(c) Line-to-line fault

P.T.O.

(7.) Draw the total sequence network model for a single line-to-ground (L-G) Fault.

(8.) Write two demerits only of Nuclear Power station.

BITS, Pilani – Dubai
International Academic City – Dubai
IVyear EEE, IInd Semester 2008-09
Course Title -Advanced Power Systems (EEE C 462)
Quiz 1(Set—A) [Use the back side of this page,if necessary]
Full Marks – 10 (Weight age 5 %) Duration—10 min.
Date: 26-02-2009[Q1,Q2 and Q7---2 Marks each and Q3 to Q6—1Mark each]
Name----- Id No.------

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

2) In a long transmission line , "C" will be: (a) Z_C Sinh γl (b)($1/Z_C$) Sinh γl (c) Z_C Cosh γl (d) Z_C Tanh γl

3)In the analysis of a long transmission line, the following concept is used:
(a) Lumped Parameters (b) Semi lumped ,semi distributed parameters (c) Distributed parameters

4) " In a transmission line, zero voltage regulation can be achieved by installing a three phase Synchronous Motor working at lagging power factor" -----Is this statement TRUE or FALSE ?

5) The power available from a hydroelectric power plant will be: (a) P=g ρ W (H/2) (b) P=g ρ W H (c) P=2g ρ W H

6) In most of the Thermal Power Stations, Synchronous generators used are having: (a) 4 poles (b) 2 poles (c) 8 poles

(7) Why superheated steam is used in Thermal Power Plant?--Explain

Set-B

BITS, Pilani – Dubai

IV yr, EEE, IInd Sem. / 2008-09
Course Title – Advanced Power System (EEE C462)

Duration - 10 min.

Quiz-I (SET-B) (Weightage 5%)

Date 26/02/2009 [Use the back side of this paper, if necessary]

Name --   Id No. --

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(1) Derive the expression for the constant "A" in a Medium Transmission Line using nominal π representation --- [2 Marks]

[1 Mark]

(2) In a long transmission line, "B" will be :-
(a) $Z_c \sinh \gamma l$ (b) $(Z_c)^2 \sinh \gamma l$ (c) $(Z_c)^2 \cosh \gamma l$

(3) Prove that the Power available from a hydro electric plant will be
$P = g \rho W H$. Define every variable and derive in detail. [2 Marks]