BITS, Pilani – Dubai
International Academic City – Dubai
IV year EEE, Ist Semester 2009-10

Course Title - Advanced Power Systems (EEE C 462)
Comprehensive Examination
Full Marks – 80 (Weight age 40 %) Duration—3 hours
Date: 24-12-2009

1.) Explain the operation of a Hydro-electric Power Station with necessary diagrams and equations. [8+2 Marks]

2.) A 50 Hz. Transmission line has a total series impedance of 30+j115 ohms and a total shunt admittance of 0.001 mho. The receiving end load is 45 MW at 220 kV(line voltage) with 0.85 power factor(lagging).Calculate the sending end voltage and sending end current using: (i) Nominal π-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) After drawing a schematic diagram of a long transmission line, develop the 2nd order differential equation in "voltage" and "current" as a function of space , starting from fundamentals.

(b)In connection with part (a) question, solve for "voltage" or "current" applying the "Laplace Transform" technique . It is given that V_S, I_S and V_R,I_R are the sending end and receiving end quantities (voltage and current) of the said long transmission line. [5+5 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= 4.0 MW-s/MVA. The damping power coefficient of the machine is 0.2 p.u/electrical radian/sec. The prime mover (mechanical) power input to the generator remains unchanged. The operating frequency is 50 Hz.
Two cases exist:----(Case 1) : The operating load angle (δ_o) = 30 degree(electrical). Case(2): The operating load angle (δ_o) = 10 degree(electrical).
In connection with the Steady State Stability Criterion:
Prove, starting the analysis from fundamentals, that Case(1) and Case (2) are exactly same so far the degree of steady state stability is concerned (Development of small perturbation model and use of Laplace Transform technique are needed), State the assumptions, if any. [8 Marks]

(5)A three phase star connected synchronous generator has positive, negative and zero sequence reactance of each being j0.09, j0.07 and j0.1 p.u., respectively. 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

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,with Z^f =0.2+j0 p.u.).Calculate the positive sequence and zero sequence component of the current through the healthy phase. Assume that E_a=1+j0 and I_a=0. . [10 Marks]

(6) Derive the equation of locus (in R-X plane)of a Modified Impedance Relay, with all necessary diagrams. [10 Marks]

(7)(a) Explain Amplitude Comparator, in connection with solid state relay with necessary circuit diagrams/block diagrams/waveforms.

(b) Explain the operation of a Vacuum Circuit Breaker(VCB) with necessary diagrams.
[5+7 Marks]

8) Applying "Equal Area Criterion" , calculate the critical clearing angle for the system shown in the following figure(Fig.1) 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. Also it is given that: l_1 =(1/2) l_2 .
[10 Marks]

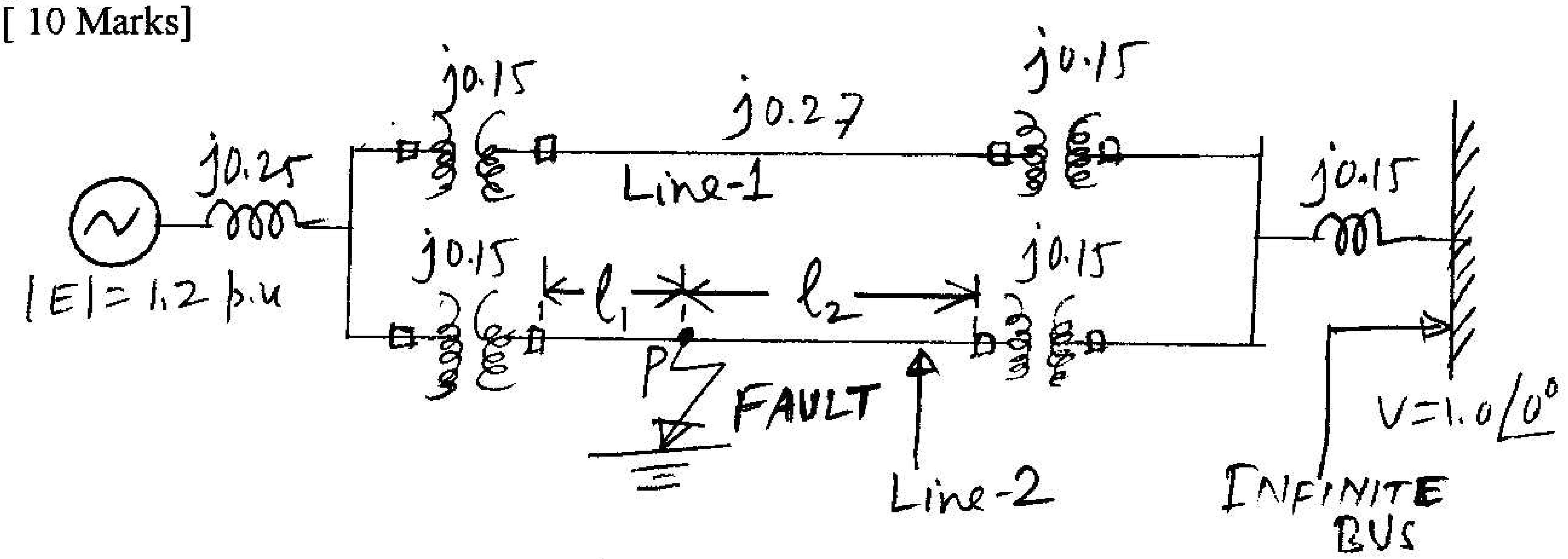

Fig. 1

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IV year EEE, 1st Semester 2009-10
Course Title - Advanced Power Systems (EEE C 462)
Test 2(OPEN BOOK)
Full Marks – 20 (Weightage 20 %) Duration—50 min
Date: 06-12--2009

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

1.)A 25 MVA, 11.0 KV,three phase Synchronous Generator is connected to a bus-bar supplying a transmission line. It is star connected. The generator is operating at no load at rated voltage. The generator has positive, negative and zero sequence impedances as j0.2 p.u, j0.2 p.u and j0.08 p.u , respectively. Calculate the value of the reactance(in ohms) to be included in the generator neutral and ground, so that the a single line-to-ground fault current equals the symmetrical three phase fault current.
Also calculate the magnitude of the fault current (in p.u.) for a line-to-line fault. Assume that $Z^f = 0$ and $X_d'' = X_1$ (positive sequence reactance)
[8 Marks]

2.)A Synchronous generator is feeding 1.0 p.u power to a large 50Hz. network over a transmission line and the line resistance is neglected. The maximum steady state power that can be transmitted under different conditions, are as follows :-

Prefault ----------- 2.0 p.u
During fault------- 0.6 p.u
Post Fault ---------- 1.6 p.u

Estimate the critical clearing angle in which the circuit breakers must trip so that synchronism is not lost. Apply the "Equal Area Criterion" method. Consider that the maximum load angle(δ_{max}) is the angle at the point of intersection by the 1.0 p.u power line with the Post-Fault "P-δ" curve. [6 Marks]

3.) 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= 4.0 MW-s/MVA. The damping power coefficient of the machine is 0.2 p.u/electrical radian/sec. The operating load angle (δ_o) = 30 degree(electrical). The prime mover (mechanical) power input to the generator remains unchanged. 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. [6 Marks]

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Course Title - Advanced Power Systems (EEE C 462)
Test 1
Full Marks – 25 (Weight age 25 %) Duration—50 min
Date: 11-10--2009

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 = $101.2\ e^{j74.2}$ 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 value of A_1 (either in polar or rectangular,complex form) . [6+3 Marks]

(2) A three phase 50 Hz. overhead transmission line (300 Km. long) has Z=40+j125 ohms 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=Cosh γl and B= Z_c Sin h γl . [7 Marks]

(3) (a) Explain the main features and principle of operation of a Thermal Power Station, with necessary block diagram and T-S 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. .
[7+2 Marks]

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Course Title - Advanced Power Systems (EEE C 462)
Quiz 2
Full Marks – 14 (Weight age 7 %) Duration—20 min.
Date: 14-12—2009

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(1) $K_3 |V| |I| \cos(\theta-\tau)-(-K_1) |V|^2 > 0$----------This inequality corresponds to:

(a) Over current relay (b) Directional relay (c) Mho relay (d) Impedance relay --------1 Mark

(2) $N_o K |I_1- I_2| > (N_r/2) K |(I_1+ I_2)|$-----This inequality corresponds to:

(a) Under frequency relay (b) Percentage differential relay (c)Reactance relay ---------1 Mark

(3) "The secondary winding of a C.T should not be kept open-circuited"---TRUE or FALSE ?------------1 Mark

(4) The associated R-X diagramn in Fig.1 indicates: (a) Directional relay (b) Under Voltage relay (c) Impedance relay (d) Mho relay-------1 Mark

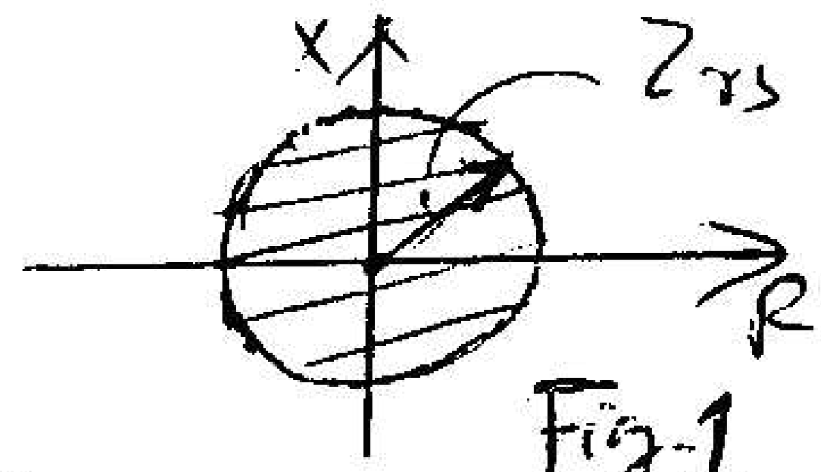

Fig-1

(5)$(R-R_s)^2 + (X-X_s)^2 = |Z_{rs}|^2$----This equation refers to:

(a) Differential relay (b) Reactance relay (c) Over current relay (d) Modified Impedance relay.------1 Mark

(6) " It is not necessary that Relaying equipment must clearly discriminate between normal and abnormal system conditions"----TRUE and FALSE ? --------------1 Mark

(7)Write the general relay equation, defining all the terms.--------2 Marks

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(8) Draw the circuit diagram of a Modified Impedance Relay with proper labeling.----2 Marks

(9) Draw the circuit diagram of a Percentage Differential Relay for protection of a Generator phase winding , with proper labeling.----2 Marks

(10) Draw typical characteristics for IDMTL relays for two values of TMS, with necessary labeling.----2 Marks

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Course Title - Advanced Power Systems (EEE C 462)
Quiz 1------Set A
Full Marks – 08 (Weight age 8 %) Duration—20 min.
Date: 26-10—2009

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

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(1) Prove that $(1+\alpha)^3 (\alpha^2) = (\cos(\pi/3) - j\sin(\pi/3))(\alpha)$ (2 Marks)

(2) For a transmission line, $Z_1 + Z_2 + Z_0$ will be equal to : (a) $j(X_S + X_M)$ (b) $j(X_S + 3X_M)$ (c) $j3X_S$ (1 Mark)

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

(4) 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. (2 Marks)

(5) If the impedance matrices in phase model and symmetrical component model are expressed as $[Z_P]$ and $[Z_S]$, respectively, then prove that $[Z_S] = [A]^{-1}[Z_P][A]$ --------(2 Marks)