CBCS SCHEME

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Sixth Semester B.E. Degree Examination, Dec.2023/Jan.2024
Power System Analysis – I

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-1

1 a. Show that the per unit impedance of a transformer is the same irrespective of the side on which it is calculated. **(04 Marks)**

b. A 300 mVA, 20 kV, 3 ϕ generator has a reactance of 20%. The generator supplies two motors m_1 and m_2 over a transmission line of 64 km having transformers at both ends as shown in Fig. Q1 (b). The transformer T_1 is a 3-phase transformer and T_2 is composed of 3 single phase transformers of rating 100 mVA each, 127 KV/13 KV, 10% reactance. The series reactance of transmission line is 0.5 ohm/km. Draw the reactance diagram with all reactances marked in per unit. Select the generator rating as base values.

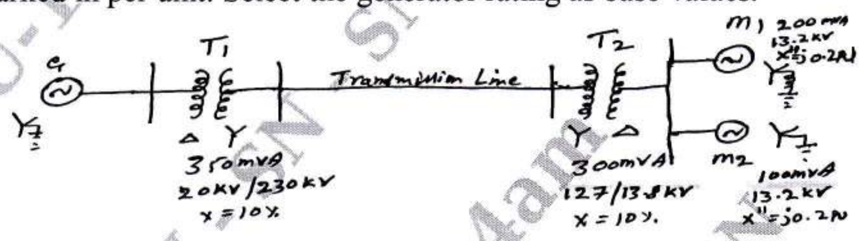

Fig. Q1 (b) **(10 Marks)**

c. How is the per unit impedance value in a given base are changed to per unit impedance value on new base? **(06 Marks)**

OR

2 a. Draw the equivalent circuit models of synchronous generator, transmission line and two winding transformer. **(06 Marks)**

b. What is per unit quantity and mention the advantages of per unit quantities? **(04 Marks)**

c. The one-line diagram of an unloaded generator is as shown in Fig. Q2 (c). Choose a base of 50 mA, 13.8 kV in the circuit of generator G_1. The ratings are as follows :

G_1 : 20 mVA, 13.8 KV, $X'' = 0.2$ P.U

G_2 : 30 mVA, 18 KV, $X'' = 0.2$ P.U

G_3 : 30 mVA, 20 KV, $X'' = 0.2$ P.U

T_1 : 25 mVA, 220 KV Y/13.8 kV Δ, $X = 10\%$.

T_2 : 30 mVA, 220 KV Y/18 kV Δ, $X = 10\%$.

T_3 : 35 mVA, 220 KV Y/22 kV Y, $X = 10\%$.

Draw the per unit reactance diagram.

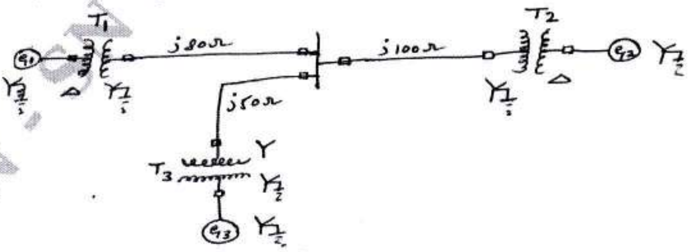

Fig. Q2 (c) **(10 Marks)**

Module-2

3 a. Explain clearly, how the circuit breakers are rated. **(08 Marks)**

b. A three phase, 5 mVA, 6.6 kV alternator with reactance of 8% is connected to a feeder of series impedance of (0.12+j0.48) ohm/phase/km. The transformer is rated at 3 mVA, 6.6 KV/33KV and has a series reactance of 5%. Determine the fault current supplied by the generator operating under no load with a voltage of 6.9 kV, when a three-phase symmetrical fault occurs at a point 15 km along the feeder. Choose base mVA as 5 mVA,

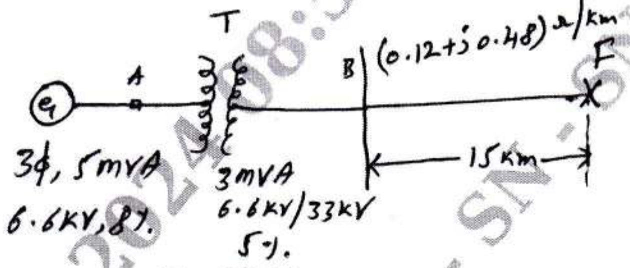

Fig. Q3 (b) **(12 Marks)**

OR

4 a. With the oscillogram of the short circuit current of a synchronous machine, distinguish between subtransient, transient and steady state reactances. Also, show that $X''_d < X'_d < X_d$ with equivalent circuit diagram. **(08 Marks)**

b. For the radial network shown in Fig. Q4 (b), a three phase fault occurs at F. Determine the fault current under fault conditions. Choose the base of 100 mVA and base kV of 33 kV in the overhead line.

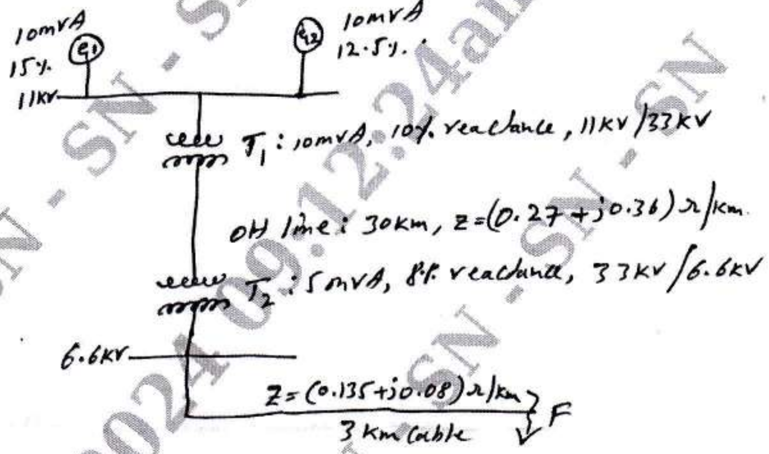

Fig. Q4 (b) **(12 Marks)**

Module-3

5 a. Derive the expression for symmetrical components of voltages in terms of phase voltages. **(08 Marks)**

b. Draw the zero sequence impedance networks of a transformer for the following connections:

(i) Δ – Δ

(ii) Y (grounded) – Y (grounded)

(iii) Y (grounded) – Δ **(06 Marks)**

c. A balanced delta connected load is connected to a three phase symmetrical supply. The line currents are each 10 A. If fuse in one of the line is blown out, determine the sequence components of line current. **(06 Marks)**

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OR

6 a. Describe the phase shifting of voltage symmetrical components in star delta transformer bank. **(08 Marks)**

b. Draw the positive, negative and zero sequence network for the power system shown in Fig. Q6 (b). Choose a base of 50 MVA, 220 KV in the 50 Ω transmission lines and mark all reactances in P.U. The ratings of the generators and transformers are :

Generator 1 : 25 MVA, 11 KV, $X'' = 20\%$

Generator 2 : 25 MVA, 11 KV, $X'' = 20\%$

T_1, T_2, T_3 and T_4 : 20 MVA, 11 Y/220 Y_{KV}, X = 15%

The negative sequence reactance of each synchronous machine is equal to the subtransient reactance. The zero sequence reactance of each machine is 8%. Assume that the zero sequence reactances of lines are 250% of their positive sequence reactance's.

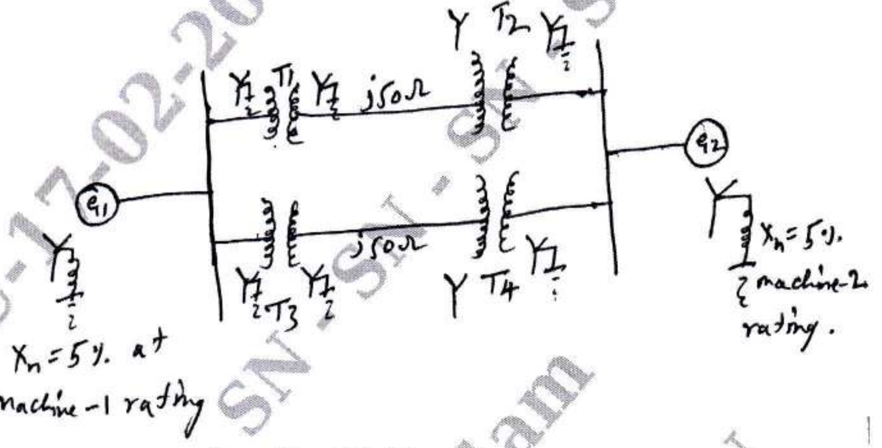

Fig. Q6 (b) **(12 Marks)**

Module-4

7 a. Derive an expression for fault current if LL fault occurs through fault impedance Z_f in a power system. Show the connection of sequence network to represent the fault. **(08 Marks)**

b. A 25 MVA, 11 kV, 3-ϕ generator has a subtransient reactance of 20%. The generator supplies two motors over a transmission line with transformer at both ends as shown in Fig. Q7 (b). The motors has rated input of 15 and 7.5 mVA, both 10 kV with 25% sub transient reactances. The three phase transformer are both rated 30 mVA, 10.8/121 KV, connection Δ − Y with leakage reactance of 10% each. The series reactance of line is 100 Ω. Calculate the fault current when a single line-to-ground fault occurs at F. The motor are fault current when a single line to grand fault occurs at F. The motors are loaded to draw 15 and 7.5 mW at 10 kV and 0.8 p.f. loading. Assume that negative sequence reactance is equal to positive sequence reactance. The zero sequence reactance's are shown in Fig. Q7 (b).

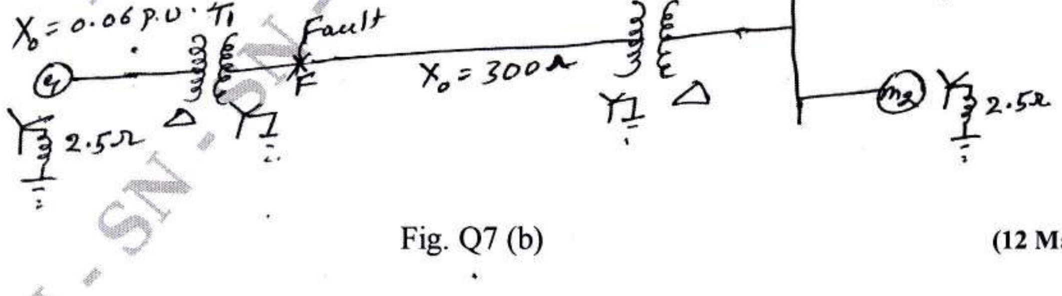

Fig. Q7 (b) **(12 Marks)**

OR

8 a. A double line to ground fault occurs at the terminals of an unloaded generator, derive an expression for fault current. Draw the connection of sequence network. **(08 Marks)**

b. A three phase generator with an open circuit voltage of 400 v is subjected to an LG fault through a fault impedance Z_f of $j2\Omega$. Determine the fault if $Z_1 = j4\Omega$, $Z_2 = j2\Omega$ and $Z_0 = j1\Omega$. Repeat the problem for LL and LLG fault. **(12 Marks)**

Module-5

9 a. Derive power angle equation for a non-salient pole machine. **(06 Marks)**

b. Explain equal area criteria for investigating the stability of power system. **(06 Marks)**

c. A turbo generator, 6 pole, 50 Hz of capacity 80 MW working at 0.8 p.f. has an inertia of 10 MJ/MVA.

(i) Calculate the energy stored in the rotor at synchronous speed.

(ii) Find rotor acceleration if the mechanical input is suddenly raised to 75 mW for an electric load of 60 MW.

(iii) Suppose the above acceleration is maintained for a duration of 6 cycles, calculate the change in torque angle and the rotor speed at the end of 6 cycles. **(08 Marks)**

OR

10 a. Derive swing equation for a synchronous machine. **(06 Marks)**

b. A 50 Hz generator is delivering 50% of the power that it is capable of delivering through a transmission line to an infinite bus. A fault occurs that increase the reactance between the generators and the infinite bus to 500% of the value before the fault. When the fault is isolated the maximum power that can be delivered is 75% of the original maximum value. Determine the critical clearing angle for the condition described. **(08 Marks)**

c. Explain the methods for improving transient stability. **(06 Marks)**

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