Name:_____________________________ Student Number: ___________________________

ELEC 4602, Electrical Power Engineering, Test #2, Fall 2015

Time: One Hour

Test #1 contains 3 questions

Authorized Memoranda: Calculator, Course Pack 2015, Course Text – Chapman

#1 <8 Marks>

A three-phase transformer bank is formed by interconnecting three single-phase transformers. The high-voltage terminals are connected to a three-phase 69 kV feeder, and the low-voltage terminals are connected to a three-phase load rated at 1000 kVA and 4.16 kV. Specify the voltage and current ratings, high-voltage and low-voltage windings, for each transformer for the following connections:

(a) wye-wye, (b) wye-delta, (c) delta-wye, (d) delta-delta./

Connection	Voltage High-voltage Winding	Current High-voltage Winding	Voltage Low-voltage Winding	Current Low-voltage Winding
(a) wye-wye	40 kV	8.3 A	2.4 kV	138.8 A
(b) wye-delta	40 kV	8.3 A	4.16 kV	80.1 A
(c) delta-wye	69 kV	4.8 A	2.4 kV	138.8 A
(d) delta-delta	69 kV	4.8 A	4.16 kV	80.1 A.

1/2 MARK FOR EACH CORRECT ENTRY

$\frac{69\,kV}{\sqrt{3}} = 40\,kV$ $\quad \frac{4.16\,kV}{\sqrt{3}} = 2.4\,kV.$

1000 KVA @ 69 kV ⇒ 8.3 A

$\frac{8.3}{\sqrt{3}} = 4.8\,A.$

1000 KVA @ 4.16 kV ⇒ 138.8 A

$\frac{138.8}{\sqrt{3}} =$ 80.1 A.

8/8

1

TOTAL MARK - 8.

#2 <12 Marks>

The low-voltage terminals of a 10 MVA, 66 kV – 7.2 kV single phase transformer are short-circuited and a voltage of 2640 volts is applied to the high voltage terminals with results as follows.

Voltage = V_{SC} = 2640 volts
Power = P_H = 9850 watts
Current = I_H = 72 amps

(a) Calculate the total series resistance and the total series reactance referred to the high-voltage side.

(b) Calculate %IR and %IX for the transformer.

(c) If the core loss at rated voltage is 40 kW, calculate the full-load efficiency of the transformer if the power factor of the load is 0.85 lag.

(a) $$R_{e_H} = \frac{P_H}{I_H^2} = \frac{9850}{72^2} = 1.9\,\Omega \quad (2)$$

$$Z_{e_H} = \frac{V_{SC}}{I_H} = \frac{2640}{72} = 36.67\,\Omega \quad (2)$$

$$X_{e_H} = \sqrt{Z_{e_H}^2 - R_{e_H}^2} = \sqrt{36.67^2 - 1.9^2} = 36.62\,\Omega \quad (2)$$

(b) $$I_{\text{full load } HV} = \frac{10,000}{66} = 151.5 \text{ Amps}$$

$$\%IR = \frac{I_1 R_{eq_1}}{V_1} \times 100 = \frac{151.5 \times 1.9}{66000} \times 100 = 0.436\% \quad (2)$$

–OR–

$$Z_{pu} = \frac{Z(\Omega) \times KVA_{BASE}}{KV_{BASE}^2 \times 1000} = \frac{1.9 \times 10,000}{66^2 \times 1000} = 0.00436$$

$$\therefore \%IR = 0.436\%$$

$$\% IX = \frac{I_1 X_{eq1}}{V_1} \times 100 = \frac{151.5 \times 36.12}{66\,000} \times 100$$

$$= \underline{\underline{8.4\%}}$$ (2)

— OR —

$$Z_{pu} = \frac{Z(\Omega) \times KVA_{BASE}}{KV_{BASE}^2 \times 1000} = \frac{36.12 \times 10{,}000}{66^2 \times 1000}$$

$$= 0.084$$

$$\therefore \% IX = \underline{\underline{8.4\%}}$$

(c)

COPPER LOSS: $151.5^2 \times 1.9$ = 43.6 kW

CORE LOSS - - - - - 40. kW

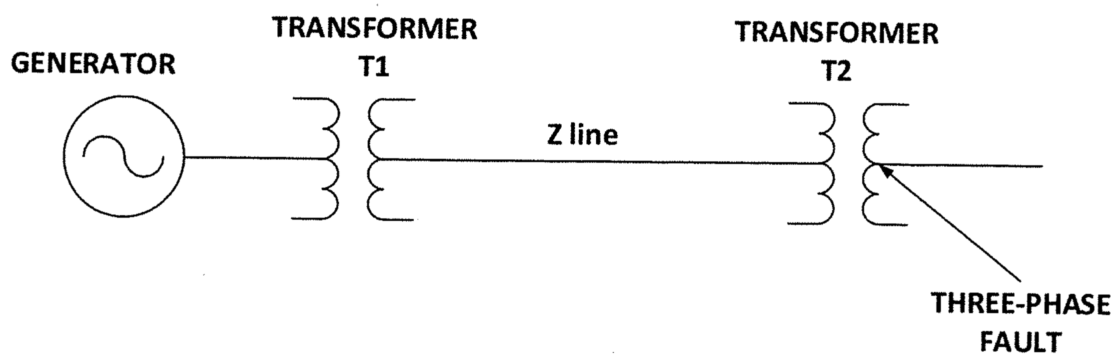
TOTAL LOSS 83.6 kW

$\therefore \eta$ = POWER OUT = $10{,}000 \times 0.85$ = 8500 kW

$$\therefore \eta = \frac{8500}{8500 + 83.6} \times 100 = \underline{99\%}$$ (2)

TOTAL 12 MARKS

3. <10 Marks>



Following are the data for the system shown above.

GENERATOR: 50 MVA, 13.8 kV, %IX = 15%
TRANSFORMER T1: 25 MVA, 13.2 – 161 kV, %IX = 10%
Z line: (10 + j10) ohms
TRANSFORMER T2: 15 MVA, 161 – 13.8 kV, %IX = 10%

Using the per unit method with basis of 100,000 kVA and 13.8 kV, the generator voltage, calculate the symmetrical short circuit current and the short circuit kVA at the low voltage terminals of Transformer T2.

$$Z_{pu\,NEW} = Z_{pu\,OLD}\left(\frac{KV_{BASE\,OLD}}{KV_{BASE\,NEW}}\right)^2\left(\frac{KVA_{BASE\,NEW}}{KVA_{BASE\,OLD}}\right)$$

GENERATOR:

$$Z_{pu\,g} = 0.15\left(\frac{13.8}{13.8}\right)^2\left(\frac{100,000}{50,000}\right) = j0.30\,pu. \quad (1)$$

TRANSFORMER T_1

$$Z_{pu_{T_1}} = 0.10\left(\frac{13.2}{13.8}\right)^2\left(\frac{100,000}{25,000}\right) = j0.366\,pu \quad (1)$$

LINE

$$\text{VOLTAGE BASE} = \frac{161}{13.2} \times 13.8 = 168.3\,kV \quad (1)$$

$$Z_{BASE} = \frac{(KV_{BASE})^2 \times 1000}{KVA_{BASE}} = \frac{168.3^2 \times 1000}{100,000} = 283.2\,\Omega$$

$$\therefore Z_{pu\,LINE} = \frac{10+j10}{283.2} = (0.035 + j0.035)\,pu \quad (2)$$

TRANSFORMER T_2

$V_{BASE} = 168.3$ kV

$Z_{pu_{T2}} = 0.10\left(\frac{161}{168.3}\right)^2\left(\frac{100,000}{15,000}\right) = j0.61$ pu. (1)

TOTAL PU. IMPEDANCE TO FAULT

GENERATOR:	$0 + j\,0.30$
T_1	$0 + j\,0.366$
LINE	$0.035 + j\,0.035$
T_2	$0 + j\,0.61$
TOTAL	$0.035 + j\,1.311 \Rightarrow 1.311\angle$ pu. (1)

V_{BASE} AT FAULT $\frac{13.8}{161} \times 168.3 = 14,426$ kV.

$\therefore I_{BASE}$ AT FAULT $\frac{KVA_{BASE}}{\sqrt{3}\,KV_{BASE}} = \frac{100,000}{\sqrt{3} \times 14,426} = 4002$ AMPS (1)

$\therefore I_{SC} = \frac{I_{BASE}}{Z_{pu}} = \frac{4002}{1.311} = \underline{\underline{3,053}}$ AMPS (1)

$KVA_{SC} = \frac{KVA_{BASE}}{Z_{pu}} = \frac{100,000}{1.311} = \underline{\underline{76,278}}$ KVA (1)

TOTAL MARKS 10