#1 <10 Marks> ELEC 4602, Test 2, 2016

Given a 50 KVA, 2400 – 240 volt single-phase transformer.

The 240 volt winding is short-circuited and 48 volts is applied to the 2400 volt winding.

Current and power input are measured at the 2400 volt winding. Results as follows:

Voltage = 48 volts

Current = 20.8 amps

Power = 620 watts,

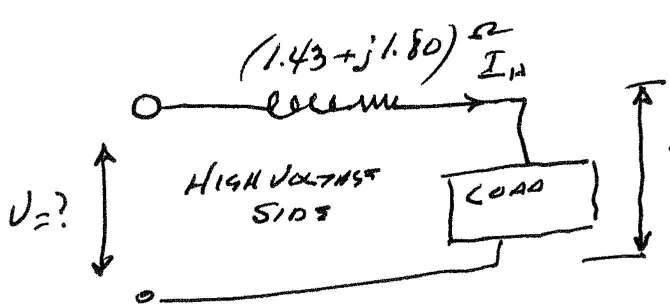
The nameplate indicates that the no-load loss is 186 watts.

Determine the voltage regulation and efficiency of the transformer when supplying rated load, 50 KVA at 240 volts and 0.80 lagging power factor.

$$Re_H = \frac{P_H}{I_H^2} = \frac{620}{20.8^2} = 1.43\,\Omega$$ (1)

$$Ze_H = \frac{V_{SC}}{I_H} = \frac{48}{20.8} = 2.30\,\Omega$$

$$\therefore Xe_H = \sqrt{Ze_H^2 - Re_H^2} = \sqrt{2.30^2 - 1.43^2} = 1.80\,\Omega$$ (2)



$$240 \times \left(\frac{2400}{240}\right) = 2400 \text{ volts.}$$

$$I_H = \frac{50}{2.4}\angle -\cos^{-1} 0.8 = 20.8\angle -36.87^\circ \text{ AMPS.}$$ (2)

NOTE THIS IS ALSO THE TEST AMPS.

$\therefore V = 2400\angle 0 + (20.8\angle -36.87)(1.43 + j\,1.80)$

$\therefore V = 2446.4$ (2)

$\therefore$ % VOLTAGE REGULATION $= \dfrac{2446.4 - 2400}{2400} \times 100 = \underline{1.9\%}$ (1)

POWER OUT : $50,000 \times 0.8 = 40,000$ WATTS.

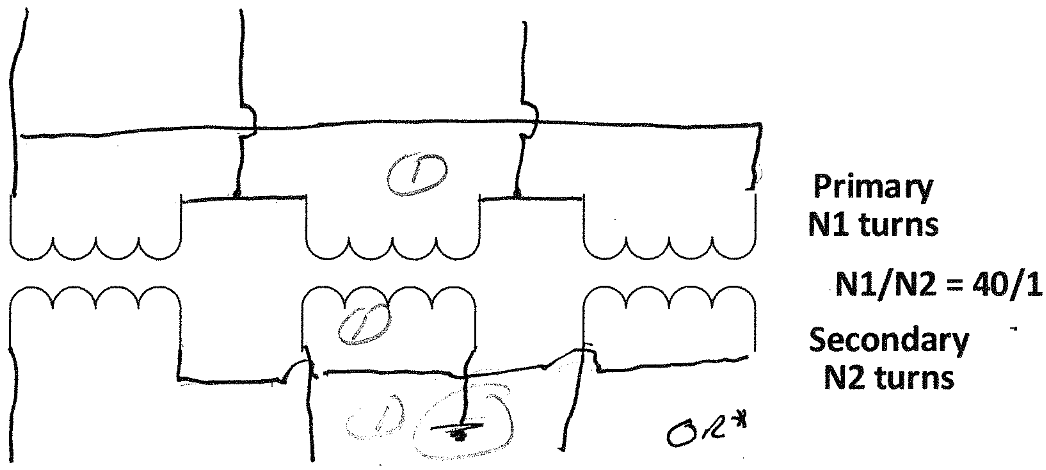
COPPER LOSS = 620 WATTS FROM TEST
(OR $20.8^2 \times 1.43 = 619$ WATTS) (1)

CORE LOSS = 186 WATT

$\therefore P_{IN} = 40,000 + 620 + 186 = 40,806$ WATTS

$\therefore$ % EFFICIENCY $= \dfrac{40,000}{40,806} \times 100 = \underline{98\%}$ (1)

#2 <9 Marks>

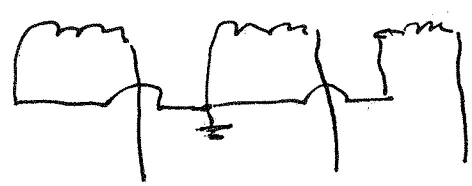


The above transformer bank supplies a balanced three-phase load of 500 kW at 600 volts, line-to-line and 0.90 lagging power factor.

a) Connect the above transformers delta on the primary side and grounded wye on the secondary side. Calculate the magnitude of:
b) Secondary line current, 534.6 AMPS
c) Secondary phase current, 534.6 AMPS
d) Secondary line-to-neutral voltage, 346.4 VOLTS
e) Primary voltage, line-to-line, 13.856 KV
f) Primary phase current, 13.365 AMPS
g) Primary line current. 23.15 AMPS.

1 MARK EACH.

OR*



(b) $P = \sqrt{3}\, V_{LL} I_L \cos\theta \Rightarrow I_L = \frac{P}{\sqrt{3} V_{LL} \cos\theta} = \frac{500}{\sqrt{3} \times 0.6 \times 0.9} = 534.6$

(c) WYE CONNECTION: $I_L = I_p = 534.6$ AMP

(d) $V_{LN} = \frac{V_{LL}}{\sqrt{3}} = \frac{600}{\sqrt{3}} = 346.4$ VOLTS

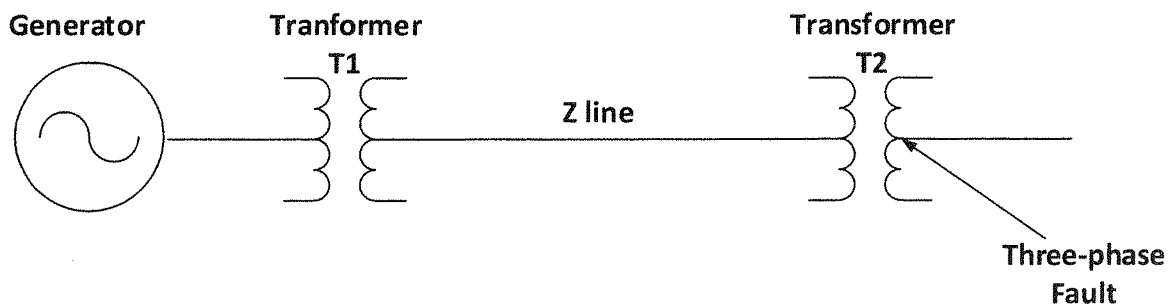
(e) PRIMARY VOLTAGE L-L: $\frac{600}{\sqrt{3}} \times 40 = 13.856$ KV

(f) PRIMARY PHASE CURRENT $\frac{534.6}{40} = 13.365$ AMP

(g) PRIMARY LINE CURRENT $13.365 \times \sqrt{3} = 23.15$ AMPS.

CHECK $P = \sqrt{3} \times 13.856 \times 23.15 \times 0.9 = 500$ KW

#3 <11 Marks>



Following are the nameplate data for the three-phase 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, 13.8 – 161 kV, %IX = 10%

a) Using the per unit method of calculation with basis 100,000 KVA and 13.8 kV, the generator rated voltage, calculate the symmetrical short circuit current and the short circuit KVA for a three-phase fault on the low voltage terminals of transformer T2.

b) Calculate the asymmetrical short circuit current.

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

GENERATOR:

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

TRANSFORMER T_1:

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

LINE: Voltage Base $= \frac{161}{13.2} \times 13.8 = 168.3$ kV.

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

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

TRANSFORMER T2: ($V_{BASE} = 168.3$ kV)

$$Z_{pu} = 0.10\left(\frac{161}{168.3}\right)^2 \times \left(\frac{100,000}{15,000}\right) = j\,0.61 \text{ pu}$$ (1)

TOTAL PER UNIT IMPEDANCE TO POINT OF FAULT

GENERATOR:	$0 + j0.30$
T1	$0 + j0.366$
LINE	$0.035 + j0.035$
T2	$0 + j0.61$

TOTAL = $0.035 + j1.311 \Rightarrow 1.311\angle$ PER UNIT (1)

V_{BASE} AT FAULT: $\frac{13.8}{161} \times 168.3 = 14.426$ kV (1)

$$I_{BASE \text{ AT FAULT}} = \frac{KVA_{BASE}}{\sqrt{3}\, KV_{BASE}} = \frac{100,000}{\sqrt{3} \times 14.426} = 4002 \text{ AMPS}$$ (1)

$$\therefore I_{SC} = \frac{I_{BASE}}{Z_{pu}} = \frac{4002}{1.311} = 3053 \text{ AMPS}$$ (1)

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

(b) $$\frac{X}{R} = \frac{1.311}{0.035} = 37.5 \quad \therefore \frac{I'}{I} \approx 1.72$$

(1)

$$I_{SC,ASYM} = 3053 \times 1.72 \approx 5251 \text{ AMPS}$$