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NPTEL

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Courses » Electrical Machines - I

Announcements **Course** Forum Progress Mentor

Unit 5 - Week 4

Week 4: Assignment

1) A 3-phase transformer bank consisting of three single phase transformers is used to step-down the voltage of a 3-phase, 11000V transmission line. If the primary line current is 100A, calculate the secondary line voltage for Y/Δ connection. The turns ratio is 10. Neglect losses. ***10 points***

- 6.35 kV
- 0.635 kV
- 63.5 kV
- 1.1 kV

Accepted Answers:
0.635 kV

2) Three single phase transformers of rating 50 kVA, 2000V/1000V are connected in Δ / Δ. Find the current in the primary windings of the transformer, when supplying a balanced three phase load of 40kW at 1000V and 0.8 power factor lagging? ***10 points***

- 16.66 A
- 33.32 A
- 8.33 A
- 28.86 A

Accepted Answers:
8.33 A

3) Two identical transformers of rating 15 kVA, 2000/1000V, 50 Hz are connected in open delta. Calculate the kVA rating of the open delta bank when HV side is used as primary? ***10 points***

- 25.98 kVA
- 30 kVA
- 38.97 kVA
- 13 kVA

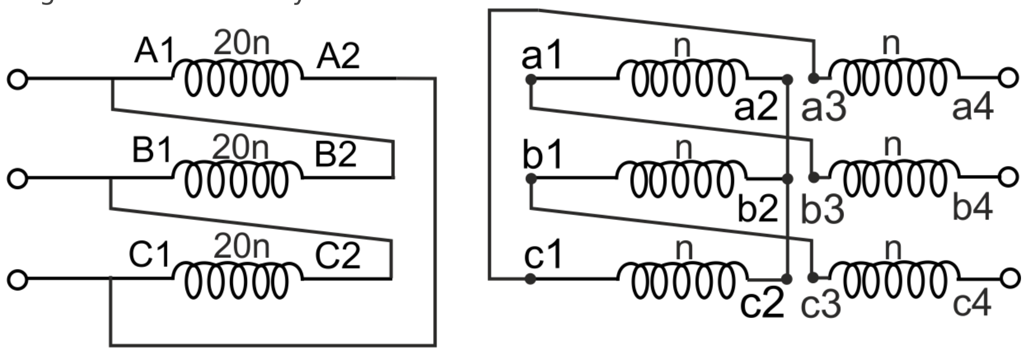
Accepted Answers:
25.98 kVA

4) Two identical single phase transformers are connected in open delta (V-V) to supply a three phase load of 180kW at 0.85 pf lagging and single phase loads of 120kW at 0.9 pf lagging at 440V. The single phase loads are distributed equally among the phases of the transformers. Find the real and reactive power supplied by each of the transformers? ***10 points***

- 118 kW and 182 kW
- 156 kW and 144 kW
- 192 kW and 108 kW
- 101 kW and 199 kW

Accepted Answers:
101 kW and 199 kW

5) Three single phase transformers are connected in delta/zig-zag, to form a three phase transformer bank. The ratio of number of turns of secondary to primary is 0.1. The secondary coils of the transformer are split into two parts of equal number of turns. The connection is shown in figure. If the line to line voltage at the primary side is 1000V, what is the line to line voltage at the secondary side. ***10 points***



- 86.6 V
- 150 V
- 50 V
- 100V

Accepted Answers:
150 V

6) A three phase step down transformer is connected to 3300V supply. The turns ratio per phase is 12 and it draws a current of 5 A from the mains. Calculate the secondary line voltage and line current if transformer is delta-star connected. ***10 points***

- 476V, 35A
- 275V, 60A
- 476V, 60A
- 275V, 35A

Accepted Answers:
476V, 35A

7) A three phase step down transformer is connected to 3300V supply. The turns ratio per phase is 12 and it draws a current of 5 A from the mains. Calculate the secondary line voltage and line current if transformer is star- delta connected. ***10 points***

- 275V, 60A
- 159V, 60A
- 159V, 104A

- 275V, 104A

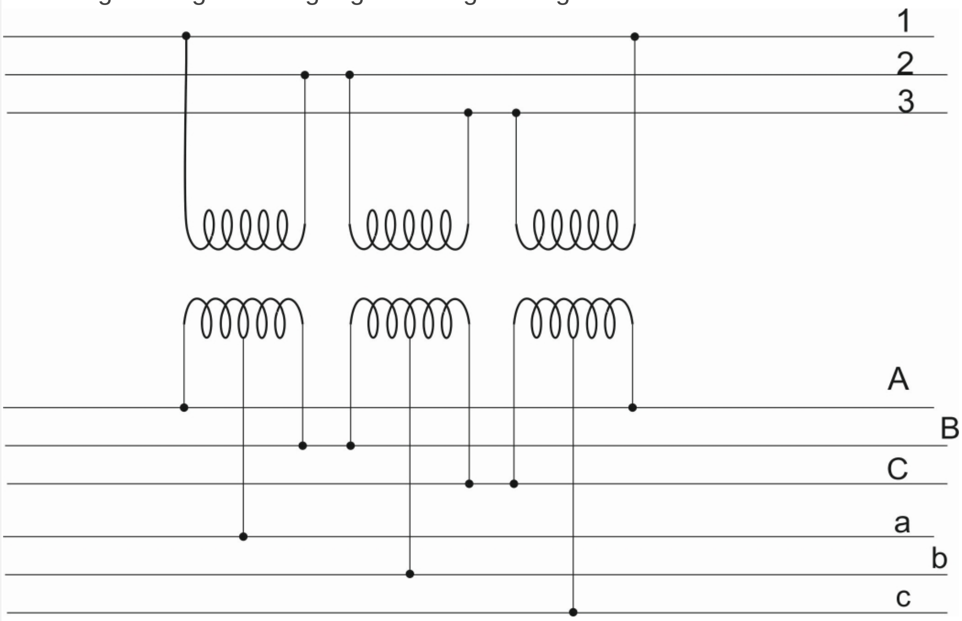
Accepted Answers:
159V, 104A

8) A 50hp, 220 V, 3-phase induction motor has efficiency 0.9 and power factor 0.8 a full load. A 3300/220 V, delta-star transformer, supplies it. What is the current in the high voltage winding of the transformer when the motor is running at full load? ***10 points***

- 9A
- 5.2A
- 136A
- 235A

Accepted Answers:
5.2A

9) From the mid points of secondaries of a 4000/440 V transformer, contacts are provided to provide lower voltage as shown in figure. A current of 50A is drawn at upf from each of the two sets of low voltage terminals abc and ABC. What will be the current in the high voltage winding? Ignore magnetizing current of the transformer. ***10 points***



- 14.3A
- 8.25A
- 75A
- 6A

Accepted Answers:
8.25A

10) Three single phase transformers are connected in delta. It supplies 100A per line to a 3-phase 3-wire system. One of the units of the transformer develops a fault and is removed. By how much does the capacity of the set of transformers reduce for the same temperature rise? ***10 points***

- 33.33%
- 66.67%
- 42.3%
- 57.7%

Accepted Answers:
42.3%

Assignment - 4 : Solution

Q1.Solution

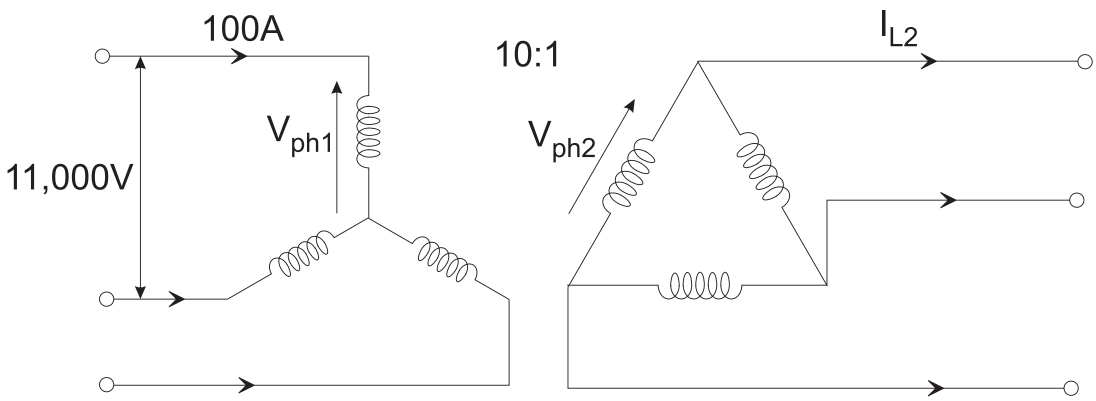


Figure 1:

$$\text{Phase voltage on the primary side,} \quad V_{ph1} = \frac{11,000}{\sqrt{3}} = 6.35kV$$

$$\text{Secondary side phase voltage,} \quad V_{ph2} = \frac{6.35}{10} = 0.635kV$$

Secondary side line voltage = Secondary side phase voltage

Secondary side line voltage, $V_{LL2} =$ **0.635 kV**

Primary side line current, $I_{L1} = 100A$

Primary side line current = Primary side phase current

Primary side phase current, $= 100A$

Secondary side phase current, $I_{ph2} = 100 \times 10 = 1000A$

Secondary side line current, $I_{L2} = \sqrt{3} \times 1000 = 1732A$

Q2. Solution

$$\sqrt{3} V_L I_L \cos(\phi) = 40,000W$$

$$\sqrt{3} \times 1000 \times I_L \times 0.8 = 40,000W$$

$$I_L = \frac{40,000}{\sqrt{3} \times 1000 \times 0.8} = 28.86A$$

$$\text{The current in the windings of the transformer secondary,} \quad I_{ph2} = \frac{28.86}{\sqrt{3}} = 16.66A$$

Current in the primary windings of the transformer, $I_{ph1} = 16.66 \times \frac{1000}{2000} =$ **8.33A**

Q3.Solution

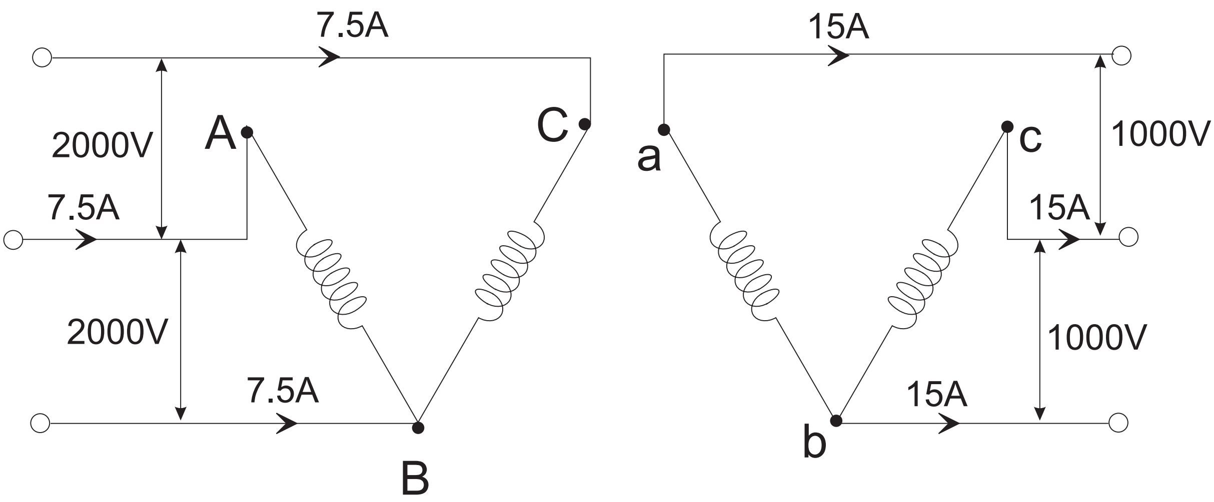


Figure 2:

The open-delta transformer bank is shown in Fig.2. In this configuration each of the transformer coil is connected across the lines.

$\therefore$ The line to line voltage to be applied at the HV side is 2000V. Induced voltage in the LV coils will be 1000V.Hence, the line-to-line voltage at the LV side 1000V.
Since, the HV and LV coils are in series with the lines, in order to avoid overload, the line current at the LV side must be limited to 15A, which automatically fixes the HV side line current to 7.5A.
Hence, the kVA handled by the bank of two single phase transformers.

$$Total \quad kVA = \sqrt{3} \times 2000 \times 7.5 = \sqrt{3} \times 1000 \times 15 = \mathbf{25.98kVA}$$

Q4.Solution

Since, the loads on each transformer is balanced; P

$$P_{L1} = 180kW$$

$$Q_{L1} = P_{L1} \times \tan(\phi_{L1}) = 180 \times \tan(\cos^{-1}(0.85)) = 111.55kVAR$$

$$P_{L2} = 120kW$$

$$Q_{L2} = 120 \times \tan(\cos^{-1}(0.9)) = 58.11kVAR$$

$$\text{Total active power, } P_{Tot} = 180 + 120 = 300kW$$

$$\text{Total reactive power, } Q_{Tot} = 111.55 + 58.11 = 170.1kVAR$$

$$\text{Hence, power factor, } PF = cos\left[\tan^{-1}\frac{170.1}{300}\right] = 0.87 \quad lagging$$

The current in the secondary side of the transformer is given by,

$$I_{L2} = \frac{P_{Tot}}{\sqrt{3}(440)(PF)} = \frac{300k}{\sqrt{3}(440)(0.87)} = 452A$$

The line currents are shifted by 30^o due to the difference between line and phase quantities and further by ϕ due to the power factor of the load

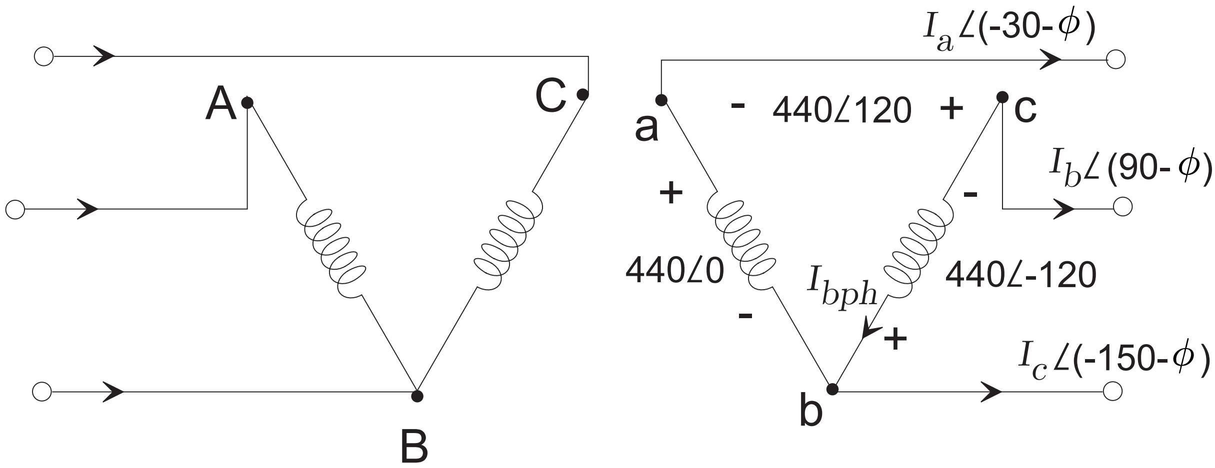


Figure 3:

The real power supplied by each tranformer can be calculated as follows

$$P_{T1} = V_{ab} \times I_a \times \cos(0 - 30 - \phi) = 440 \times 452 \times \cos(0 - 30 - 29.54)$$

$$P_{T1} = \textbf{100.819kW}$$

$$P_{T2} = V_{bc} \times I_{bph} \times \cos(-120 - (90 - \phi - 180)) = 440 \times 452 \times \cos(-120 - (90 - 29.54 - 180))$$

$$P_{T2} = \textbf{198.87kW}$$

Q5.Solution

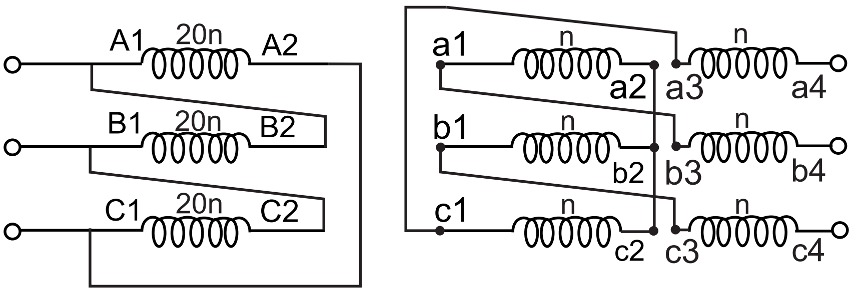


Figure 4:

The ratio of voltage induced in coil a2a1 to coil A2A1 is given by, $V_{a2a1} : V_{A2A1} = 1 : 20$

$$\text{Hence,} V_{a2a1} = \frac{1}{20} \times 1000 = 50V$$

The ratio of voltage induced in coil a4a3 to coil A2A1 is given by, $V_{a2a1} : V_{A2A1} = 1 : 20$

$$\text{Hence,} V_{a4a3} = \frac{1}{20} \times 1000 = 50V$$

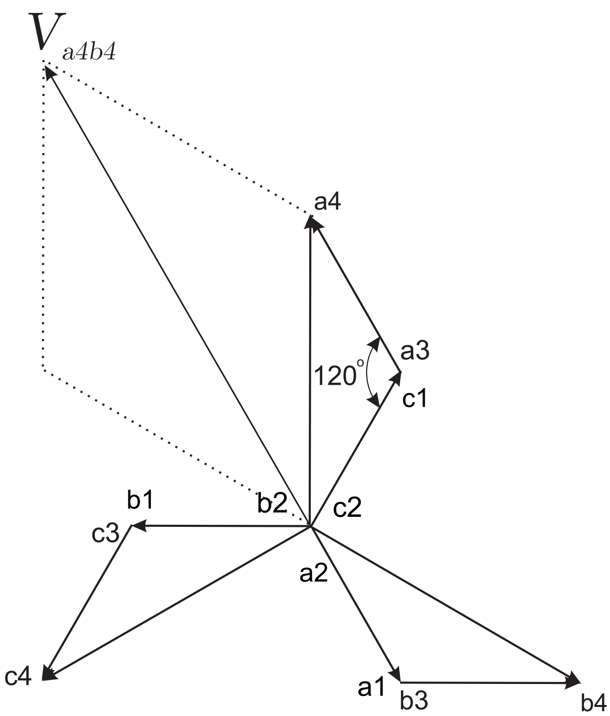


Figure 5:

$$\text{Now,} \quad V_{a4a2} = \sqrt{3} \times 50 = 86.6V$$

$$\text{Hence, the line voltage,} \quad V_{a4b4} = \sqrt{3} \times 86.6 = \mathbf{150V}$$

Q6. Solution

Delta-Star connection

$$\text{Secondary phase voltage} = \frac{3300}{12} = 275V$$

$$\therefore \text{Secondary line voltage} = \text{Secondary phase voltage} \times \sqrt{3}$$

$$= \mathbf{476.31\ V}$$

$\therefore$ Secondary line current = Secondary phase current (since, seconday is star)

Secondary phase current = (Primary phase current x 12)

$$\text{Primary phase current} = \frac{\text{Primary line current}}{\sqrt{3}}$$

$$\therefore \text{Secondary line current} = \frac{5}{\sqrt{3}} \times 12$$

$$= \mathbf{34.64\ A}$$

Q7. Solution

Star-Delta connection

Primary phase voltage = Primary line voltage /$\sqrt{3}$

$$= \frac{3300}{\sqrt{3}} = 1905.25V$$

Secondary Line voltage = Secondary phase voltage

$=$ Primary phase voltage / 12 $=$ **158.77 V**

$\therefore$ Secondary line current=$\sqrt{3} \times$ Secondary phase current (since, seconday is delta)

Secondary phase current= (Primary phase current x 12)

$$= 5 \times 12$$

$$= 60A$$

$\therefore$ Secondary line current =60 $\times \sqrt{3}$

$$= \mathbf{103.9A}$$

Q8. Solution

$$\text{Turns ratio of phase} = \frac{3300}{220/\sqrt{3}} = 26$$
$$\text{Power drawn by motor} = \frac{\text{Power output}}{\text{Efficiency}}$$
$$\text{Power output of motor in watts} = \text{Power output in HP} \times 746$$
$$\therefore \text{Power drawn by motor} = \frac{50 \times 746}{0.9} = 41.4kW$$
$$\text{Power drawn by motor} = \sqrt{3} \times 220 \times I \times 0.8$$
$$\implies I = \frac{41.4 \times 10^3}{\sqrt{3} \times 220 \times 0.8} = 135.95A$$
$$\therefore \text{Current in HV side of transformer} = \frac{\text{Current in LV winding}}{\text{Turns ratio}}$$
$$135.95/26 = \mathbf{5.23\ A}$$

Q9. Solution

$$\text{Power drawn by both windings 'ABC' and 'abc'} = \sqrt{3} \times 440 \times 50 + \sqrt{3} \times 220 \times 50$$
$$= 57157.67W$$
$$\text{Power drawn from primary = Power drawn from secondary}$$
$$\text{Power drawn from primary} = \sqrt{3} \times V_{pl} * I_{pl}$$
$$\therefore \text{Primary Line current}(I_{pl}) = \frac{57157.67}{\sqrt{3} \times 4000}$$
$$I_{pl} = \mathbf{8.25\ A}$$

Q10. Solution

Refering to solution of question 2, we can see that the capacity of the bank reduces to 57.7% of the original rating

This is because in open delta the line can only carry the phase current

$\therefore$ Reduction in capacity of transformers = 100-57.7 $= 42.3\%$