Example 2.6:

A 1ϕ, 100 kVA, 2000/200 V two-winding transformer is connected as an autotransformer as shown in Fig. E2.6 such that more than 2000 V is obtained at the secondary. The portion ab is the 200 V winding, and the portion bc is the 2000 V winding. Compute the kVA rating as an autotransformer.

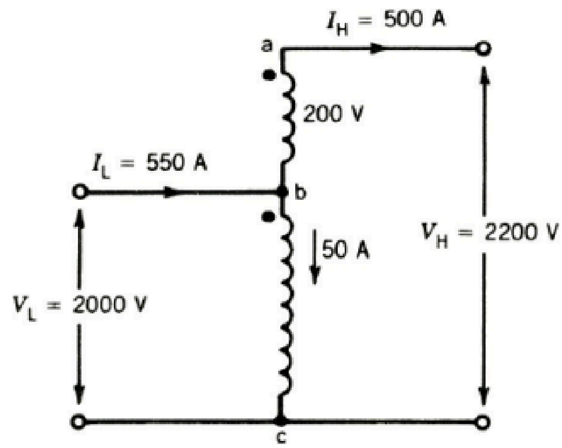


FIGURE E2.6

Example 2.7:

Three 1ϕ, 50 kVA, 2300/230 V, 60 Hz transformers are connected to form a 3ϕ, 4000/230 V transformer bank. The equivalent impedance of each transformer referred to low voltage is $0.012 + j0.016\ \Omega$. The 3ϕ transformer supplies a 3ϕ, 120 kVA, 230 V, 0.85 PF (lag) load.

(a) Draw a schematic diagram showing the transformer connection.

(b) Determine the transformer winding currents.

(c) Determine the primary voltage (line-to-line) required.

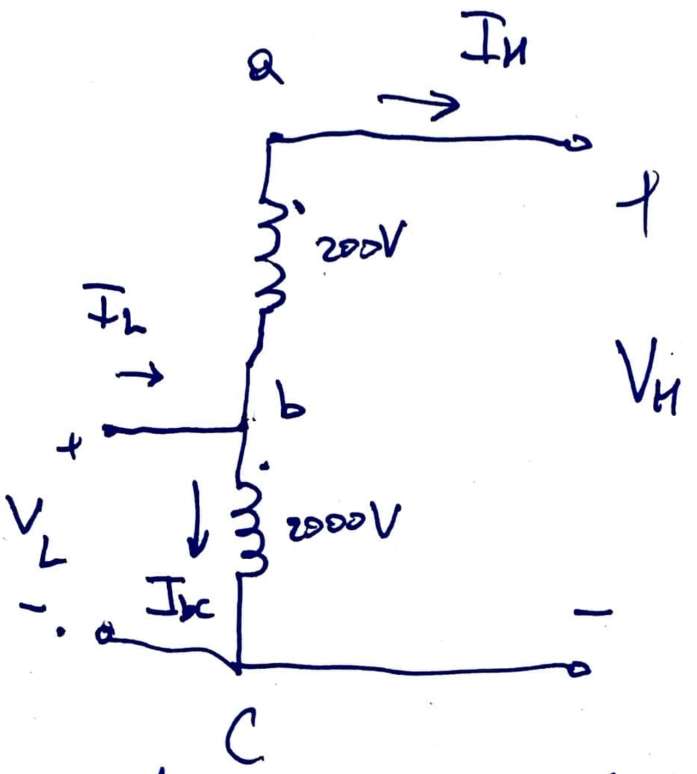
Example 2.8:

EXAMPLE 2.8

A 3ϕ, 230 V, 27 kVA, 0.9 PF (lag) load is supplied by three 10 kVA, 1330/230 V, 60 Hz transformers connected in Y–Δ by means of a common 3ϕ feeder whose impedance is $0.003 + j0.015\ \Omega$ per phase. The transformers are supplied from a 3ϕ source through a 3ϕ feeder whose impedance is $0.8 + j5.0\ \Omega$ per phase. The equivalent impedance of one transformer referred to the low-voltage side is $0.12 + j0.25\ \Omega$. Determine the required supply voltage if the load voltage is 230 V.

Example 2-6

1ϕ, 100 kVA,



$V_L = \underline{\underline{2000\,V}}$

$V_H = 2000 + 200 = \underline{\underline{2200\,V}}$

$$I_H = \frac{100\,kVA}{200\,V} = 500\,A$$

$$I_{bc} = \frac{100\,kVA}{2000\,V} = 50\,A$$

$\Rightarrow I_L = 500 + 50 = \underline{\underline{550\,A}}$

$S_L = ?$

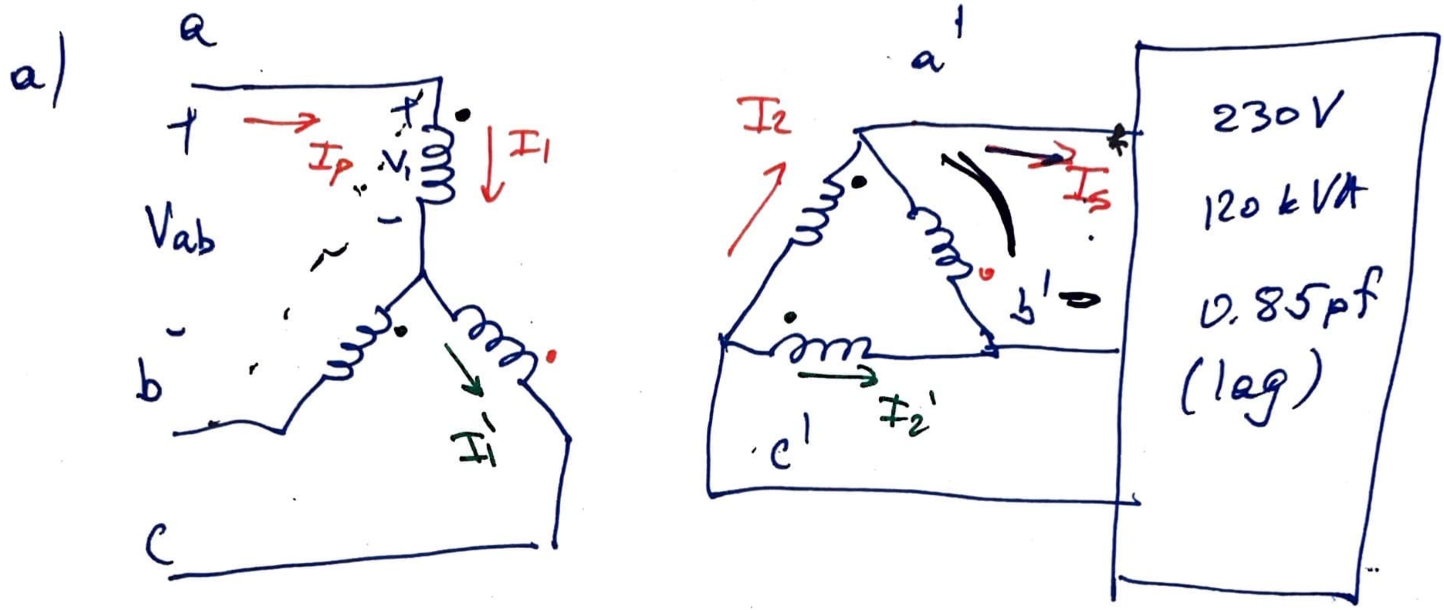
$S_H = ?$

$$S_L = I_L \cdot V_L = 2000 \cdot 550 = \boxed{1100\,kVA}$$

$$S_H = I_H \cdot V_H = 2200 \cdot 500 = \boxed{1100\,kVA}$$

Example 2.7

a)



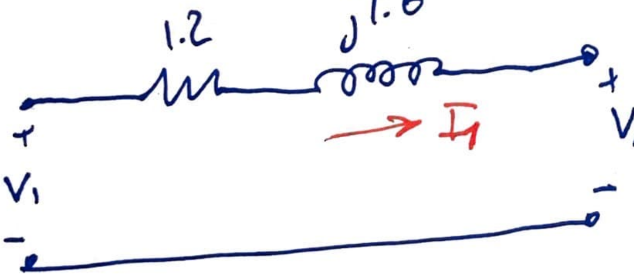
b) $|I_s| = \dfrac{S/3}{V_L/\sqrt{3}} = \dfrac{120000}{\sqrt{3}\cdot 230} = \underline{301.24\ A}$

$|I_2| = \dfrac{|I_s|}{\sqrt{3}} = \dfrac{301.24\ A}{\sqrt{3}} = \boxed{173.92\ A}$

$a = \dfrac{2300}{230} = 10$

$|I_1| = |I_2| \cdot \dfrac{1}{a} = 173.92 \cdot \dfrac{1}{10} = \boxed{17.39\ A}$

c) $Z_{eq,H} = a^2 \cdot Z_{eq,L} = 100 \cdot (0.012 + j0.016) = \underline{1.2 + j1.6\ \Omega}$



$V_L' = a \cdot V_L = 10 \cdot 230\angle 0^\circ =$

$= 2300\angle 0^\circ\ V$

$\phi = \cos^{-1}(0.85) = \underline{31.8^\circ}$

$\phi = \cancel{\theta_v} - \theta_i, \quad \theta_i = -\phi = -31.8^\circ$

$I_1 = \underline{17.39\angle -31.8^\circ\ A}$

$$V_1 = Z_{eq,H} \cdot \bar{I}_1 + V_2' = (1.2 + j1.6) \cdot 17.39 \angle -31.8^\circ +$$

$$+ 2300 \Rightarrow |V_1| = 2332.4\,V$$

$$|V_{ab}| = \sqrt{3} \cdot |V_1| = \sqrt{3} \cdot 2332.4 = \boxed{4039.8\,V}$$

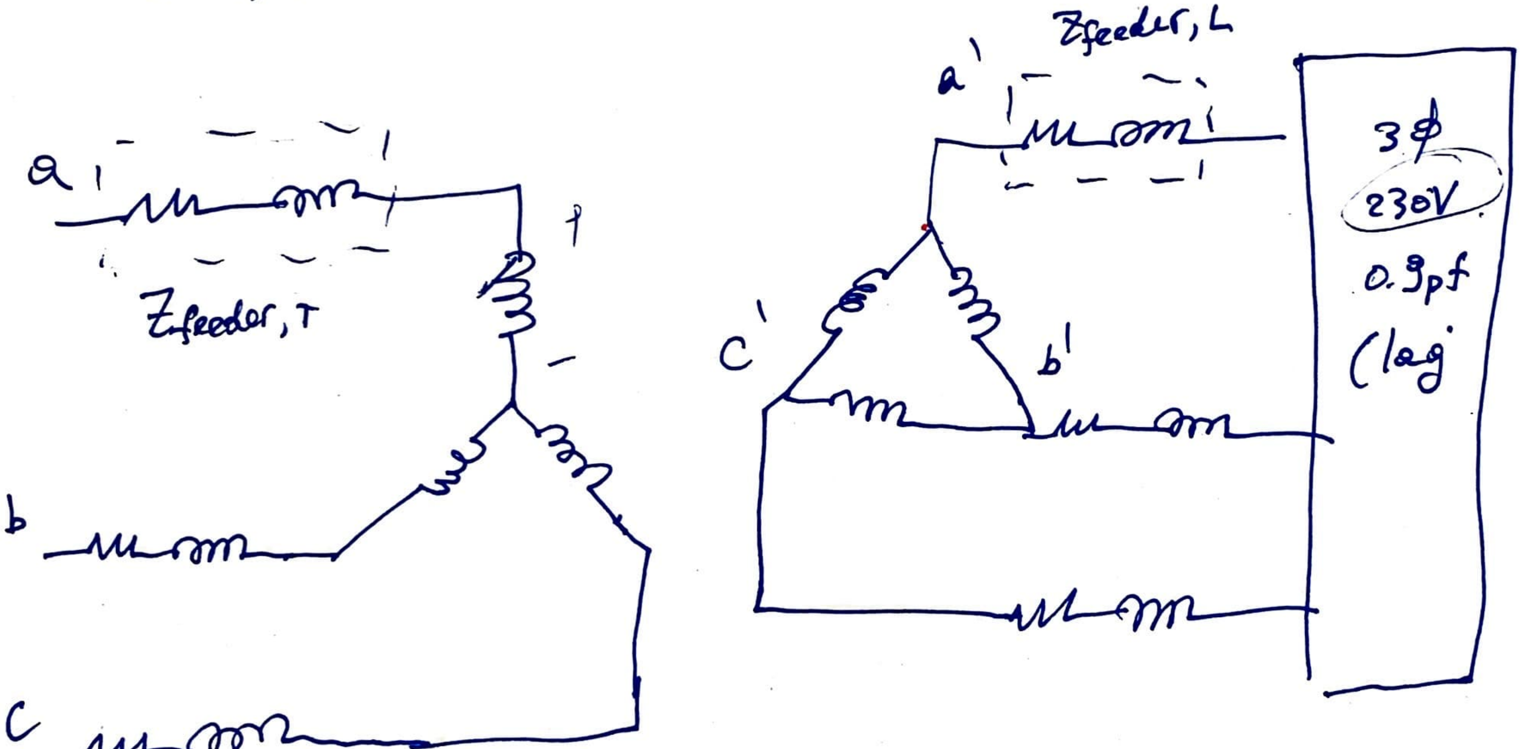
Example 2.8

Load: 3ϕ, 230V, 27 kVA, 0.9 pf (lag), $V_{load} = 230V$

Transformers: $3\times$ 1ϕ, 10 kVA, 1330/230 V, 60Hz, $Z_{eq,L} = 0.12 + j0.25$

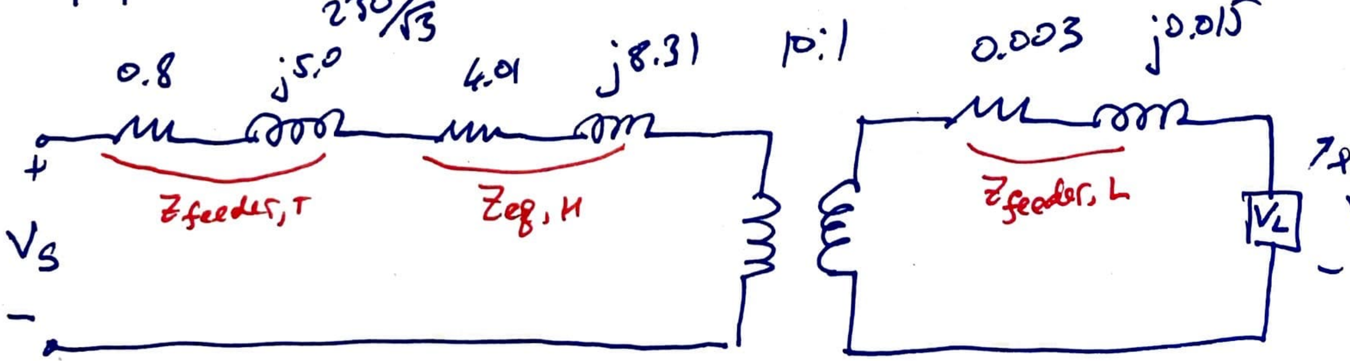
$Z_{feeder,L} = 0.003 + j0.015\ \Omega$ – per phase

$Z_{feeder,T} = 0.8 + j5.0\ \Omega$ – per phase



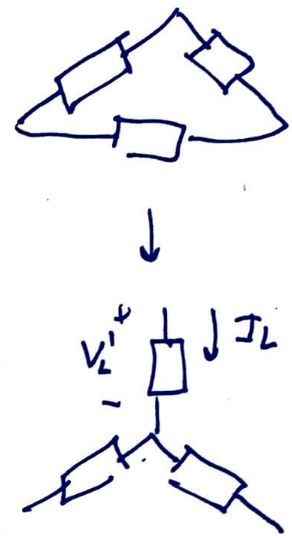
1) $Z_{eq,H} = \left(\frac{1330}{230}\right)^2 \cdot Z_{eq,L} = \left(\frac{1330}{230}\right)^2 (0.12 + j0.25) = \underline{4.01 + j8.36\ \Omega}$

$a_{Y-Y} = \frac{1330}{230/\sqrt{3}} = \boxed{10}$



$|V_L'| = \frac{|V_L|}{\sqrt{3}} = \frac{230}{\sqrt{3}} = 133$ V ?

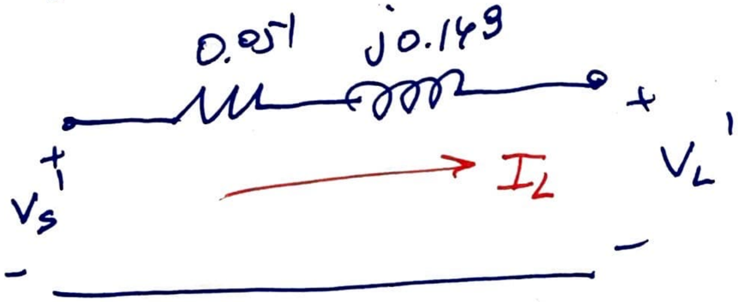
$V_L' = 133 \angle 0°$



Let's refer everything to LV side:

$R_{eq,L} = \left(\frac{1}{10}\right)^2 (0.8 + 4.01) + 0.003 = \underline{0.051\,\Omega}$

$X_{eq,L} = \left(\frac{1}{10}\right)^2 (5.0 + 8.36) + 0.015 = \underline{0.149\,\Omega}$



$|I_L| = \frac{\frac{27000}{3}}{133} = \underline{67.67 A}$

$\boxed{\frac{S}{3} = V_L' \cdot I_L}$

$\phi = \cos^{-1}(0.9) = 25.8°$ (+ve, lag)

$\cancel{\theta_v}^{0} - \theta_i = \phi \Rightarrow \theta_i = -\phi = \underline{-25.8°}$

$\Rightarrow \boxed{\bar{I}_L = 67.67 \angle -25.8°}$

$V_s' = \bar{I}_L \cdot \underset{(R_{eq} + jX_{eq})}{Z_{eq}} + V_L' = 67.67 \angle -25.8° \cdot (0.051 + j0.149) + 133 \angle 0° \approx$

$\Rightarrow \cancel{V_s} \boxed{V_s' = 140.7 \angle 3.1° \text{ V}}$

$|V_s| = a \cdot |V_s'| = 10 \cdot 140.7 = \boxed{1407 \text{ V}}$

<u>line-to-line:</u> $|V_{s,line}| = \sqrt{3} \cdot 1407 = \boxed{2437 \text{ V}}$