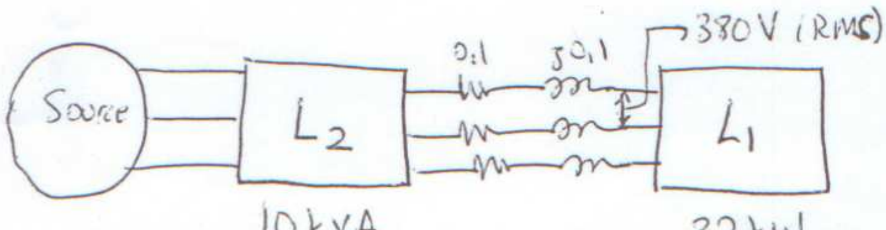
EE 202 Summer

Exam #5

(1) A balanced 3ϕ load of L_1 of 32 kW at 0.8 p.f. lagging. A second 3ϕ load is connected to L_1 through transmission line of impedance $0.1 + j0.1$; The second load L_2 draws 10 kVA at 0.7 p.f. lagging. The voltage accross L_1 is given as 380 Volts (RMS) line to line.



a) Find line to line voltage accross L_2.
b) Find p.f. of the source.

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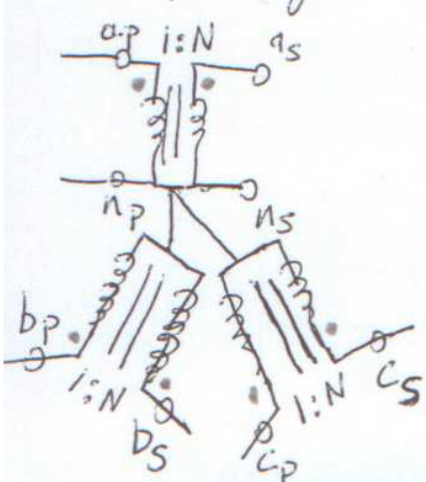
(2) A 3ϕ transformer is a magnetically coupled circuit modifying current/voltage levels on 3 phases.



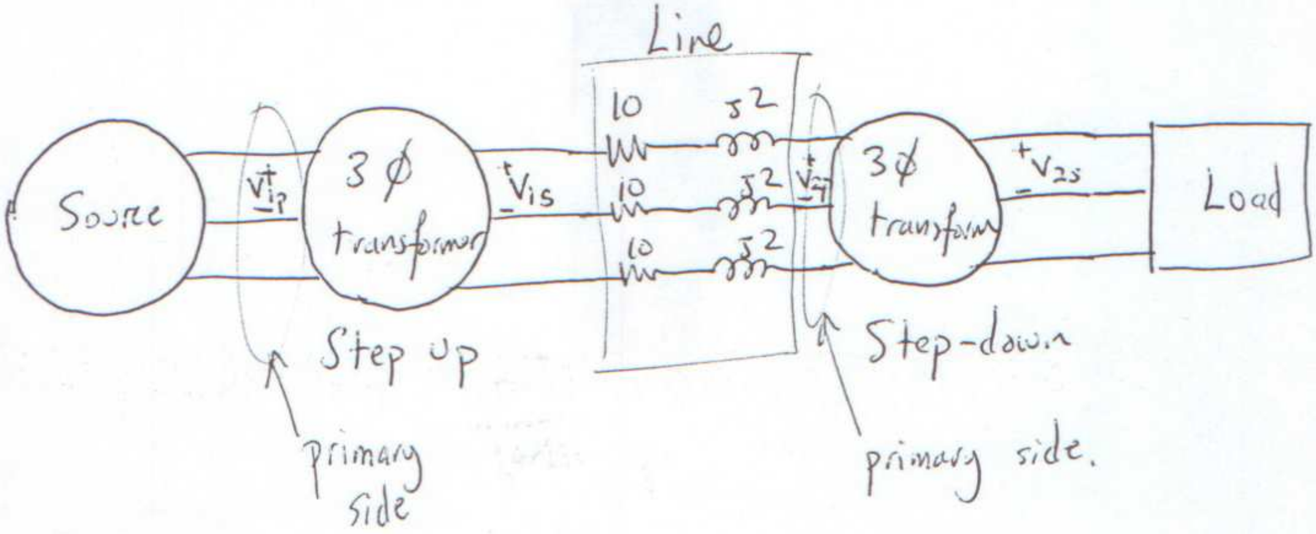
a_p: line a primary side

a_s: line a secondary side

b_p, b_s; c_p, c_s } similar

$$\frac{V_{a_s n_s}}{V_{a_p n_p}} = \frac{V_{b_s n_s}}{V_{b_p n_p}} = \frac{V_{c_s n_s}}{V_{c_p n_p}} = N$$

Similar for the current (as single phase)



Step-up transformer has higher voltage on secondary side.
Step-down transformer has lower voltage on secondary side,

that is $\dfrac{V_{1s}}{V_{1p}} = N$ and $\dfrac{V_{2s}}{V_{2p}} = \dfrac{1}{N}$

If Load is Y connected with impedance $40+j8\,\Omega$ per phase. Source suplies 140 V (RMS) line-to line.

a) Draw single phase equivalent of the circuit.

b) Find ratio of $\dfrac{\text{Power lost on line}}{\text{Power delivered to load}}$ when $N=1$

c) Find the ratio in part b, when $N=10$.

Exam #5 Solutions

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Summer 2006/07

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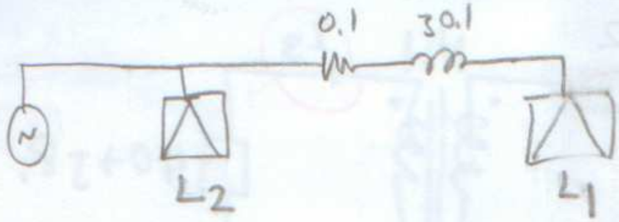
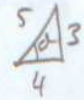


a) $$\begin{cases} S_{L_1} = 32{,}000 + j\,32{,}000 \underbrace{\tan(\cos^{-1} 0.8)}_{3/4} = 32{,}000 + j\,24000 \\ S_{L_2} = 10{,}000 \angle 45^\circ = 7070 + j\,7070 \end{cases}$$



$$\begin{cases} |S_{L_1}| = \sqrt{3}\, |V_{Line}^{(2)}|\, |I_{Line}^{(2)}| \\ 40{,}000 = \sqrt{3}\, |380|\, |I_{Line}^{(2)}| \longrightarrow |I_{Line}^{(2)}| = 60.77 \text{ A.} \end{cases}$$

$$S_{Line} = 3\, |I_{Line}^{(2)}|^2 (0.1 + j\,0.1) = 1108 + j\,1108$$

$$S_{L_1} + S_{Line} = 33108 + j\,25108$$

$$|S_{Line\,and\,L_1}| = \sqrt{(33108)^2 + (25108)^2} = \sqrt{3}\, |V_{Line}^{(2)}|\, 60.77$$

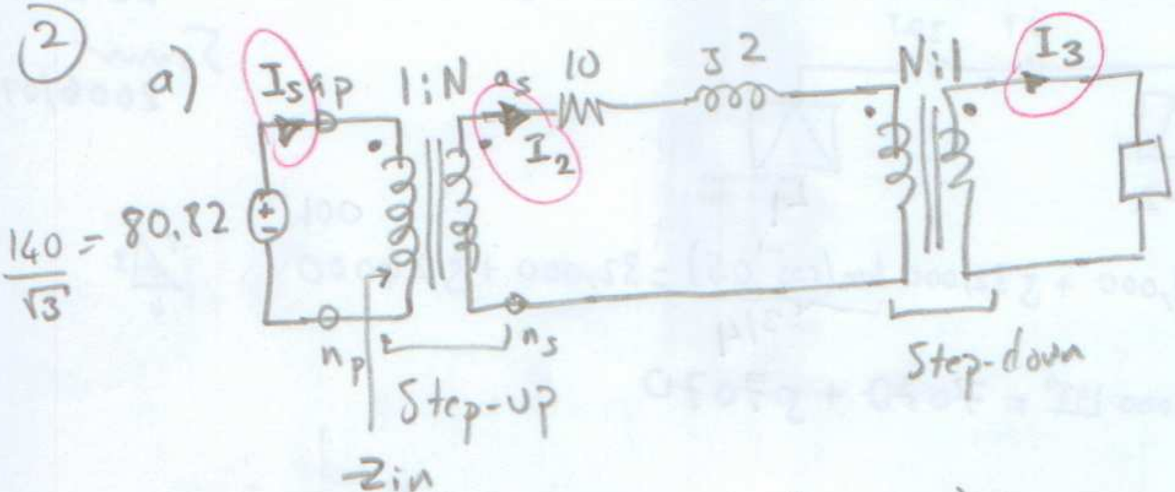
$$|V_{Line}|^2 = 394.8 \text{ V (RMS)}$$

b) $$S_{L_1\,and\,L_2\,and\,Line} = (33108 + j\,25108) + (7070 + j\,7070)$$

$$= 40178 + j\,32178.$$

$$p.f = \cos\left(\tan^{-1}\left(\frac{32178}{40178}\right)\right) = 0.78 \text{ (lagging)}$$

② a)



b) $Z_{in} = (40+j8)N^2 \cdot \frac{1}{N^2} + (10+j2)\frac{1}{N^2}$

$$I_S = \frac{80\angle 0}{(40+j8)+(10+j2)\frac{1}{N^2}} = \frac{80}{(10+j2)\left(\frac{1}{N^2}+4\right)}$$

$$I_2 = I_S \cdot \frac{1}{N} = \frac{80/N}{(10+j2)\left(\frac{1}{N^2}+4\right)}$$

$$I_3 = I_2 \cdot N = I_S$$

$$P_{Line,\,per\ phase} = |I_2|^2 \cdot 10 = \frac{6400/N^2}{(104)\left(\frac{1}{N^2}+4\right)^2} \cdot 10$$

$$P_{Load\ per\ phase} = |I_3|^2 \cdot 40 = \frac{6400}{(104)\left(\frac{1}{N^2}+4\right)^2} \cdot 40$$

b) $N=1 \rightarrow \frac{P_{Line}}{P_{Load}} = 1/4$ c) $N=10$; $\frac{P_{Line}}{P_{Load}} = \frac{1}{400}$

So Power lost on line becomes an insignificant ratio of power delivered when $N=10$.