Indian Institute of Technology Patna
Department of Electrical Engineering
EE280 - Electrical Machines
Spring - 2022
Quiz - I – Solution.
18 February 2022

There are 5 problems. They carry equal marks.

$(5 \times 2 = 10)$

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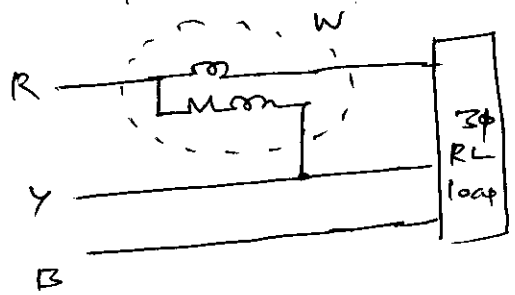
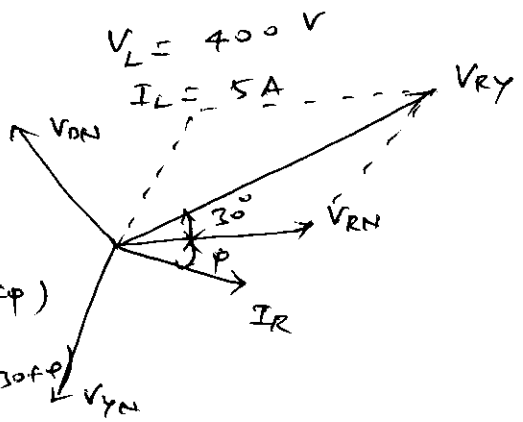
1. A three phase balanced RL load is supplied by a balanced three phase source with phase sequence RYB. A voltmeter reads 400 Volts between lines. An ammeter in one line reads 5 Amps. A wattmeter whose current coil is connected in the line R and the potential coil is connected between R and Y reads 1000 Watts. Find the total real power consumed by the load in watts.





$W = V_{RY} I_R \cos(30 + \phi)$

$1000 = 400 \times 5 \times \cos(30 + \phi)$

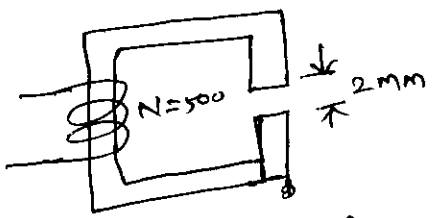
$\boxed{\phi = 30^\circ}$

$P_{3\phi} = \sqrt{3}\, V_L I_L \cos\phi$

$= \sqrt{3} \times 400 \times 5 \times \cos 30^\circ$

$\boxed{P_{3\phi} = 3000 \text{ watts}}$

2. An inductor is designed with 500 turns coil wound on an iron core of 25 cm^2 cross sectional area and with a cut of an air-gap length of 2 mm. The coil is connected to a 120 V, 60 Hz ac supply. Find the steady state current. Neglect coil resistance, core loss, core reluctance, leakage flux, and fringing.

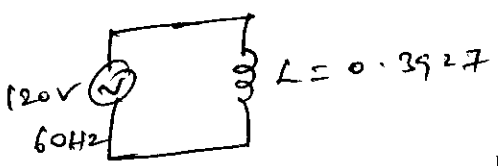


$(\mathcal{R}_c = 0)$

$L = \dfrac{N^2}{\mathcal{R}_g} = \dfrac{500^2}{2 \times 10^{-3}} \times 4\pi \times 10^{-7} \times 25 \times 10^{-4}$

$\boxed{L = 0.3927 \text{ H}}$

$I = \dfrac{V}{\omega L} = \dfrac{120}{2\pi \times 60 \times 0.3927}$



$\boxed{I = 0.8106 \text{ A}}$

3. A 50 kVA, 2400/240 V transformer gives the maximum efficiency of 98 % at three fourths of the full load unity power factor. Find the percentage efficiency at half the rated load 0.8 power factor lagging.

$$0.98 = \frac{\frac{3}{4} \times 50}{\frac{3}{4} \times 50 + P_{core} + P_{cu}}$$

at max η, ($P_{cu} = P_{core}$)

$P_{core} = 382.7$ Watts

Let us find the P_{cu} at full load.

$x^2 P_{cu\,FL} = 382.7$

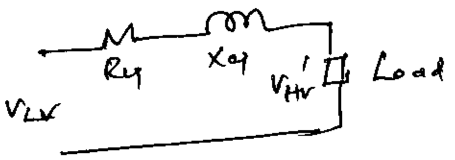
$\left(\frac{3}{4}\right)^2 \times P_{cu\,FL} = 382.7$

$P_{cu\,FL} = 680.3$ Watts

$$\%\eta_{at\ 50\%\ load} = \frac{\frac{1}{2} \times 50 \times 0.8}{\frac{1}{2} \times 50 \times 0.8 + 0.3827 + (\frac{1}{2})^2 \times 0.6803} \times 100$$

$\%\eta = 97.31$

4. A 230/115 V, 1 kVA single phase transformer has 3% resistance and 4% reactance. Find the voltage to be applied on low voltage side when the transformer is delivering full load at 0.8 pf leading on the high voltage side with rated voltage across the load.



R_{eq} on LV side

$= 0.03 \times$ Base impedance on LV side

$$R_{eq} = 0.03 \times \frac{(0.115)^2}{0.001} = 0.3967\ \Omega$$

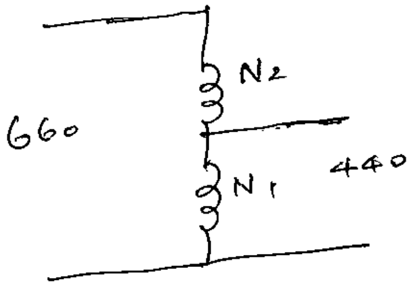
$$X_{eq} = 0.04 \times \frac{(0.115)^2}{0.001} = 0.5290\ \Omega$$

$V_{LV} = 115\angle 0^\circ + \dot{I}_{rated\ in\ LV\ side} \times (0.3967 + j0.5290)$

$V_{LV} = 115\angle 0^\circ + 8.7\angle 36.87^\circ (0.3967 + j0.5290) = 115.14\angle 2.56^\circ$ Volts

$|V_{LV}| = 115.14$ V

5. A 1 kVA 440/220 V two winding transformer has 96 % efficiency at the full load unity power factor. If it is reconfigured as a 660/440 auto transformer, what will be the efficiency of the auto transformer at the full load 0.8 power factor lagging?



$S_{Auto} = S_{TW} \times \left(1 + \frac{N_1}{N_2}\right)$

$= 1 \times (1 + 2)$

$S_{Auto} = 3$ KVA

TW Transformer

$$0.96 = \frac{1000}{1000 + P_{core} + P_{cu\ at\ FL}}$$

($P_{core} + P_{cu\ at\ FL} = 41.67$ Watts)

$$\%\eta = \frac{3 \times 0.8 \times 10^3}{3 \times 0.8 \times 10^3 + 41.67}$$

Since we are determining efficiency at full load, it can be used.

$\%\eta = 98.3$