Date : 13th Jan 2012

EN-206 - Assignment No.1 - TRANSFORMERS

Q1) A 20kVA 2200/220 Volts, 60Hz, single phase transformer is found to have the following equivalent circuit parameter referred to the high potential side.

$R_1 = 2.5_1\Omega \quad R_2' = 3.11\Omega \quad X_{L1} = 10.9\Omega \quad X_{L2}' = 10.9\Omega \quad X_m' = 25{,}100\Omega$

The transformer is used to supply a 15kVA load at 220V & power factor (lagging) of 0.85. Determine the required potential difference at the high potential side of the transformer. Don't forget to draw the complete phase diagram for the given operating condition.

(Take $\overline{V}2$ as the reference phase) (Ans : 2311V angle 2.6^0)

Q2) a) The parameter of the equivalent circuit of a 150-KVA, 2400/240-V transformer are:

$R_1 = 0.2\Omega \qquad R_2 = 2\times10^{-3}\Omega$

$X_1 = 0.45\Omega \qquad X_2 = 4.5\times10^{-3}\Omega$

$R_2' = 10K\Omega \qquad X_m' = 1.6K\Omega$

(Both magnetizing resistance (R_2') & inductance (X_m') are as from 2400-V side)

i) Calculate the open circuit current & power factor when LV is located at rated voltage.
ii) The voltage at which the HV should be excited to conduct a short circuit test (LV shorted) which full-load current flowing. What is the input power & its pf?

b) For the transformer given in part (a) draw the circuit model as seen from HV side. Determine the voltage regulation & efficiency when the transformer is supplying full load at 0.8 lagging pf on the secondary side at rated voltage. Under these condition calculate also the HV side current & its pf.

(Ans: a) i) I_0=15.2A (15.2 angle-80.9^0); pf=0.158(lag)

ii) V_{SC}=59.9V, P_{SC}=1.56kW & pf_{sc}=0.407(lag)

b) Voltage regulation = 2.24%, η = 98.2% , HV Current = 63.63A , pf = 0.79(lag)

Q3) a) A 500kVA transformer has an efficiency of 95% at full load and also at 60% of full load: both at upf.

i) Separate out the losses of the transformer.
ii) Determine the efficiency of the transformer at ¾ full load

b) A transformer has it maximum efficiency of 0.98 at 15KVA at upf. Compare it all-day efficiencies for the following load cycle:

a) full load of 20KVA 12 hours/day and no-load for the rest of the day.

b) full load 4 hours/day and 0.4 full-load rest of the day.

(Ans a) i) Pi=9.87kW Pc = 16.45Kw.

ii) η = 95.14%

b) a) η_{allday} = 97.2%

b) η_{allday} = 97.7%

Q4) A 20KVA, 2000/200V, 50Hz transformer is operated at no load on rated voltage, the input being 150W at .012 power factor (lag). When it is operating at rated load, the voltage drops in the total leakage reactance and the total resistance are, respectively 2& 1 percent of the rated voltage. Determine the input power and power factor when the transformer delivers 10kW at 200V at 0.8Pf (lag) to a load in the LV side.

(Ans: 10.23 kW, 0.742(lag))

Q5) A 50kVA, 2200/220V, 50Hz transformer when tested gave the following results.

OC test, measurements in LV side: 405W, 5A, 220V

SC test, measurements on HV side: 805W,20.0A, 95V.

a) Draw the circuit model of the transformer referred to the HV and LV sides. Label all the parameters.
b) Calculate the parameters of the transformers input referred to the HV and LV sides. Use base KVA as 50 & base Voltage as 2200 V on HV side AND 220V on LV side.(the base voltage are in the ratio of the transformation)

What is your observation?

(Ans: Per unit parameters seen on HV side:

$G_i = 0.8*10^{-2}\Omega^{-1}$ ($G_i = 1/R_i$)

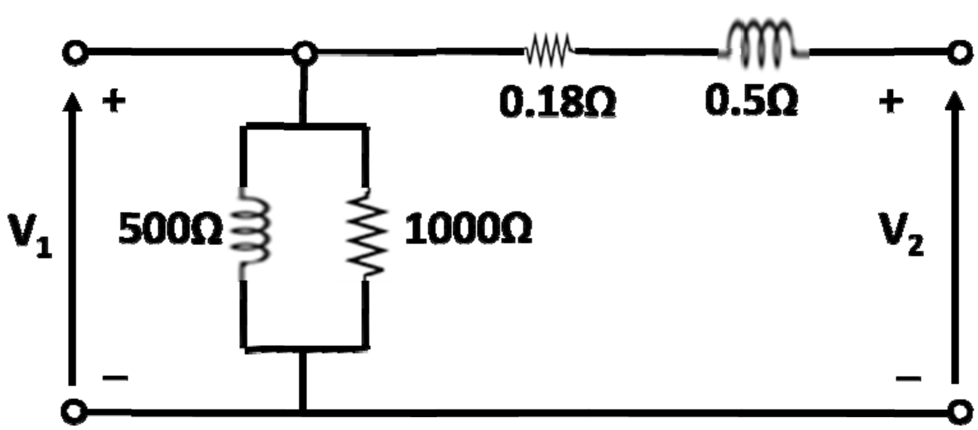
$B_m = 2.04*10^{-2}\Omega^{-1}$ ($B_m = 1/X_m$)

$R = 0.02\Omega$ $X = 0.044\Omega$

Per unit parameters on LV side are SAME as that on HV side!)

Q 6) The circuit model of a 5KVA, 200/400V, 50Hz single phase transformer, referred to the LV side is shown in figure 1.

a) An OC test is conducted from the HV side at 400V. Calculate the power input, Power factor and current (magnetizing) drawn by the transformer.
b) An SC test is conducted from the LV side by allowing full-load current to flow. Calculate the voltage required to be applied, the power input & power factor.



(figure 1)

(Ans: a) (0.1- i*0.2) A

b)13.3V, 112.5W, .34 lag)

Q7) The following test results were obtained on a 20KVA, 2200/220V,50Hz transformer:

OC test (LV): 220V, 1.1A, 125W

SC test (HV) : 52.7V, 8.4A, 287W

a) The transformer is loaded at unity Pf on secondary side with a voltage of 220V. Determine the maximum efficiency and the load at which it occurs:
b) The transformer is fully loaded. Determine the load Pf for zero voltage regulation.

(Ans a) 96.14%, 13.2kW b) 0.76 leading)

Q 8) A 20 KVA, 2400/240V, 50Hz two winding transformer has an efficiency of 97.5% at full load, 0.8 Pf. It is connected as a 2400/2640 V auto transformer.

i) What are the other different possible connections as an auto transformer?
ii) For the auto transformer mentioned above, at full load calculate the kVA output, kVA transformered & kVA conduted. Find also the efficiency at full load, unity power factor.
iii) Ratio of weight of auto transformer conductors to weight of conductors in 2 winding transformer.

(Ans: ii) 20 KVA, 244KVA,99.84% iii) 0.09091)

Q 9) A Δ/Y connected 3 phase transformer has a voltage ratio of 22KV (Δ) / 345 KV (Y) (line to line/rms). The transformer is feeding 500 MW and 1000 MVA to the grid(345kw). Determine the kVA and voltage ratio of each unit and compute all the currents and voltages (both magnitude & phase) in the lines and the windings (3 Primaries and 3 Secondary). Assume ideal transformers.

(Ans : ratio of each unit 170KVA , 22/199.2KV

<u>Y side</u> 0.853 angle -11.3^0, 0.853 angle-131.3^0, 0.853 angle 251.3^0 kA V_{AB} = 345 angle 30^0, V_{BC}= 345 angle 90^0 , V_{CA} = 345 angle -210^0 KV

<u>Δ side</u> Vab = 22 angle 0^0, Vbc = 22 angle -120^0, Vca = 22 angle -240^0 kV Ia = 13.376 angle-41.3^0, I_b = 13.376 angle -161.3^0 Ic = 13.376 angle -281.3^0 KA (line) reference phasor Van= 199.2 angle 0^0. kV.

Q10) Three identical transformers each rated 6.6/22kV, 3MVA are connected in Y/Y. The transformer bank is fed from a source of line voltage $6.6\sqrt{3}$ KV. The secondary side feds a delta connected load composed of three equal impedances. Assuming the individual transformers to be ideal find:

a) The value of Z in ohm to fully load the bank (i.e 9MVA)
b) The current in each leg of the load (Δ connected) and
c) The current in each transformer primary & secondary.

(Ans : a) 484Ω , b) 78.75 A, c) 454.5A, 136.4 A)

Q 11)a). A 600 kVA, single phase transformer with 0.012pu resistance and 0.06pu reactance is connected in parallel with a 300kVA transformer with 0.014pu resistance and 0.045pu reactance to share a load of 800kVA at 0.8pf(lag). Find the ratio of sharing of the load when i) both the secondary voltages are 440V ii) When open circuit secondary voltages are respectively 445V and 455V.

b). The exciting current of a single phase, 10kVA, 2200/220V, 60Hz transformer is 0.25 A when measured on the low voltage side. It equivalent impedance is 10.4 + i *31.3Ω when referred to the high voltage side. Taking the transformer rating as the base

i) Determine the base values of voltages, currents and impedances for both high voltage and low voltage sides.

ii) Express the exciting current in per-unit form for both high voltage & low-voltage sides.

iii)Obtain the equivalent circuit in per unit form.

iv)Find the copper loss in per unit form.

v)Determine the per unit voltage regulation (using the per unit equivalent circuit from iii)

when the transformer delivers 75% full load at 0.6 lagging power factor.

(Ans : a) i) $S_1 = 377 - i\ 305.2$

$S_2 = 264 - i\ 171.6$ S_1 & S_2 are the apparent

powers of the 2 transformers

ii) assuming output load voltage at 440V.

$S_1 = 413.6$ angle -34^0 & $S_2 = 388$ angle -44^0

b)

i)

	HV	LV
Vbase	1Pu	1Pu
Ibase	1Pu	1Pu
Zbase	1Pu	1Pu

ii) I exciting (pu) = 0.055pu (on both LV &HV)

iii) (pu) = (0.0215 + i *0.0647) pu .{either HV or LV, its the same}

iv) Pcu (fl) = 0.0215 pu.

v) Voltage regulation = 4.86%).