Problems for Module 2, Transformers:

You will need to use a calculator that can handle complex numbers, or you can directly use MATLAB.

Textbook Chap. 2: Example 2.6, and Problem 2.9, plus additional Problems 1 and 2.

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.

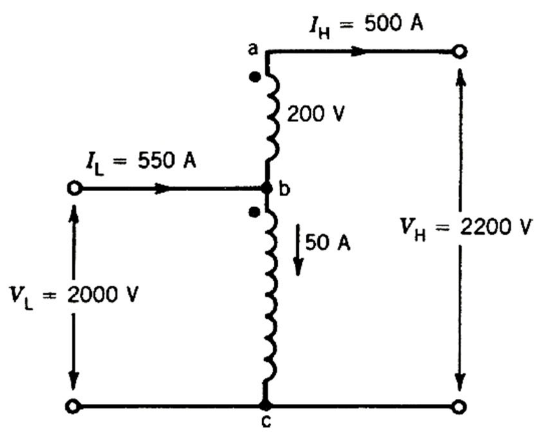

FIGURE E2.6

2.9 A 1ϕ, two-winding transformer has 1000 turns on the primary and 500 turns on the secondary. The primary winding is connected to a 220 V supply and the secondary winding is connected to a 5 kVA load. The transformer can be considered ideal.

(a) Determine the load voltage.

(b) Determine the load impedance.

(c) Determine the load impedance referred to the primary.

Problem 1 (See Example 2.2)

As you should have read in your textbook, it is possible to determine the parameters of the transformer T-equivalent circuits using the basic tests, i.e. open-circuit test and short-circuit test, respectively. Consider a single-phase 60Hz, step-down transformer with turns $N_1 = 400$ and $N_2 = 200$. The results of the open-circuit and short-circuit tests are: $V_{1,oc} = 120V$, $I_{1,oc} = 1A$, $P_{1,oc} = 30W$, and $V_{1,sc} = 20V$, $I_{1,sc} = 10A$, $P_{1,sc} = 50W$, respectively. Assume that winding resistances and leakage reactances are respectively equal when referred to the same side, $R_1 = R_2'$ and $X_1 = X_2'$. You may use common assumption as we did in class and/or used in the textbook. Based on the provided information, do the following:

a) Calculate the transformer T-equivalent circuit parameters, all referred to the primary side
b) Sketch the equivalent circuit and label all parameters

c) The transformer is supplied form a 120V ac sources. A load resistor of $R_{load} = 10\Omega$ is connected to the secondary side. Calculate the primary current I_1 and secondary voltage V_2 under this load. Also calculate the output real P_2 and reactive Q_2 power consumed by the load, and the input real P_1 and reactive Q_1 powers taken from the source. Briefly explain the difference between the input and output powers.

d) Assume that your load resistor is changing from 0 to 200Ω in some increments. Calculate and plot the transformer efficiency $\eta = P_{out}/P_{in} = P_2/P_1$ vs. load current I_2 (rms value). It may be easy to do in MATLAB! Briefly explain where the efficiency is very low (and you would not recommend operating in those regions), and where it is high (and you would recommend operating in that region).

Problem 2

Assume that you have three identical step-down transformers with $N_1 = 200$ and $N_2 = 100$. The transformers may be assumed ideal and connected into $\Delta - Y$. The load is composed of series *R-L* ($R = 6\ \Omega$ and $X = 6\ \Omega$) per-phase, which are Y-connected and balanced. The primary side is connected to a 3-phase 208V (line-to-line, rms) balanced ac source.

(a) Sketch an appropriate circuit that shows all transformers and their connections, input terminals, output terminals, and the loads. Label the input primary side terminals (on your left) with ***ABC*** and the output terminals (load side on your right) with ***abc***. Label the windings' polarity with dot "•" on each transformer.

(b) Calculate the **total three-phase real and reactive power** $P_{3\phi}$ and $Q_{3\phi}$ supplied to the load

(c) Calculate the **primary (input) line** current I_1 and its power factor angle in degrees