4-1. An ideal transformer ($N_1 = 800, N_2 = 200$) with a primary source of $V_1 = 220 \angle 0^\circ$ V-rms delivers a complex power of $S_2 = 2 \angle 30^\circ$ kVA to the load connected to the secondary. Determine (a.) the secondary voltage ($V_2$) (b.) the load impedance ($Z_2$) and (c.) the input impedance seen by the primary voltage source ($Z_1$).

**Ans.** (a.) $V_2 = 55 \angle 0^\circ$ V-rms (b.) $Z_2 = (1.31 + j0.76) \ \Omega$ (c.) $Z_1 = (20.96 + j12.16) \ \Omega$

4-2. A single-phase 12 kVA, 220/110 V, 60 Hz transformer is driven at its rated primary voltage at a phase angle of 0$^\circ$ and draws the rated current at a power factor of 0.85 lagging. Assuming an ideal model for the transformer, determine (a.) the kVA rating of the load and (b.) the load impedance.

**Ans.** (a.) 12 kVA (b.) $Z_2 = 1.01 \angle -31.79^\circ \ \Omega$

4-3. Results from no-load and short-circuit tests on a single-phase 100 kVA, 1000/100 V, 60 Hz transformer are given below.

- No-load test: $V_L = 100 \ \text{V}, \ I_L = 6.6 \ \text{A}, \ P_L = 440 \ \text{W}$
- Short-circuit test: $V_H = 55 \ \text{V}, \ I_H = 100 \ \text{A}, \ P_H = 1980 \ \text{W}$

Determine (a.) the rated voltage voltage and current on the LV and HV sides of the transformer (b.) the transformer approximate equivalent circuit referred to the LV side (c.) the transformer approximate equivalent circuit referred to the HV side.

**Ans.** (a.) $V_{H,\text{rated}} = 1000 \ \text{V}, \ V_{L,\text{rated}} = 100 \ \text{V}, \ I_{H,\text{rated}} = 100 \ \text{A}, \ I_{L,\text{rated}} = 1000 \ \text{A}$
(b.) $R_{cL} = 22.73 \ \Omega, \ X_{mL} = 20.37 \ \Omega, \ R_{eqL} = 1.98 \ \text{m}\Omega, \ X_{eqL} = 5.13 \ \text{m}\Omega$
(c.) $R_{cH} = 2273 \ \Omega, \ X_{mH} = 2037 \ \Omega, \ R_{eqH} = 0.198 \ \text{m}\Omega, \ X_{eqH} = 0.513 \ \Omega$

4-4. A single-phase 25 kVA, 220/440 V, 60 Hz transformer has the following approximate equivalent circuit parameters: $R_{cL} = 74.46 \ \Omega, \ X_{mL} = 24.36 \ \Omega, \ R_{eqL} = 314 \ \text{m}\Omega, \ X_{eqL} = 603 \ \text{m}\Omega$. Determine the results of the no-load and short-circuit tests for this transformer (a.) no-load test (HV winding open) (b.) short-circuit test (LV winding shorted).

**Ans.** (a.) $V_L = 220 \ \text{V}, \ I_L = 9.50 \ \text{A}, \ P_L = 647 \ \text{W}$ (b.) $V_H = 38.62 \ \text{V}, \ I_H = 56.82 \ \text{A}, \ P_H = 1014 \ \text{W}$
4-5. A transmission line \([Z_{\text{line}} = (0.5 + j1.2) \, \Omega]\) connects a voltage source \(V_s\) to the primary of a single-phase 100kVA, 2200/440 V transformer. The transformer secondary is connected to a 440 V, 75 kW load at power factor of 0.8 lagging. Assume the equivalent impedance of the transformer referred to the HV side is characterized is \(R_{eqH} + jX_{eqH} = \) \((1.2 + j4.3) \, \Omega\) and assume the phasor voltage at the load is \(440\angle 0^\circ\) V. (a.) Draw the complete circuit diagram. (b.) Determine the phasor voltage at the transformer primary. (c.) Determine the phasor voltage at the transmission line input.

Ans. (b.) \(V_H = 2353.7\angle 2.82^\circ\) V (c) \(V_s = 2402.9\angle 3.44^\circ\) V

4-6. Determine the following quantities for the transformer in Problem 4-3. Assume that \(V_H = V_{H,\text{rated}}\angle 0^\circ\) V for no-load calculations: (a.) the no-load current as a percentage of the full-load current (b.) the transformer core loss at no-load (c.) the transformer power factor at no-load (d.) the transformer copper loss at full-load.

Ans. (a.) 0.66% (b.) \(P_{\text{core,NL}} = 440\) W (c.) \(PF_{NL} = 0.667\) lagging (d.) \(P_{Cu,FL} = 1980\) W

4-7. Determine the voltage regulation for the transformer in Problem 4-3 at full load (rated current and voltage) with a power factor of 0.6 leading. Draw the phasor diagram showing the voltage drop across the transformer for the given load condition.

Ans. \(VR = -2.80\%\)

4-8. For the transformer in Problem 4-3, determine (a.) the transformer efficiency at rated output power with a power factor of 0.85 lagging (b.) the maximum efficiency.

Ans. (a.) \(\eta = 97.23\%\) (b.) \(\eta_{\text{max}} = 98.17\%\)