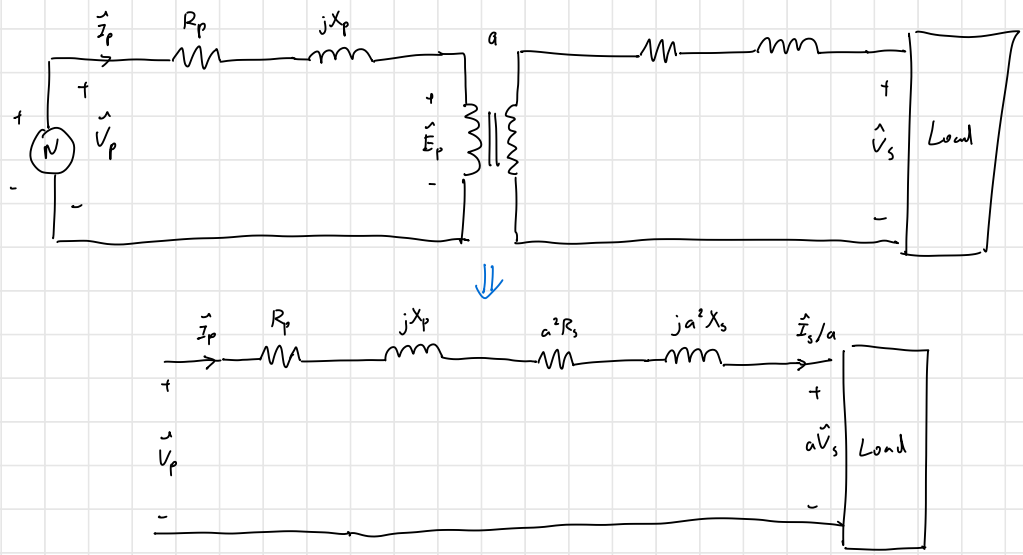
Example 9-1

A single-phase transformer has the following specifications:
20 kVA, 2400/240V, 60 Hz, full load at power factor of 0.8 lagging, $R_p = 0.8\ \Omega$, $X_p = 3\ \Omega$, $R_s = 0.008\ \Omega$, and $X_s = 0.03\ \Omega$.

(a) Find the equivalent circuit parameters referred to primary. Draw the equivalent circuit diagram and phasor diagram referred to primary.

(b) Find $\overline{V_p}$.



a. $a = \frac{N_p}{N_s} = \frac{2400}{240} = 10$, 20 kVA = maximum load that can be connected to secondary

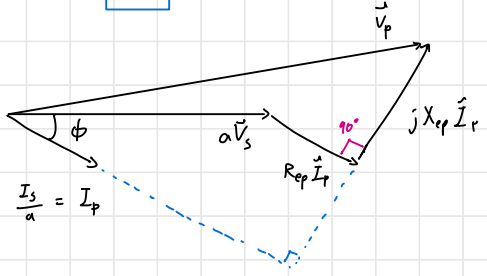
$R_{ep} = R_p + a^2 R_s = 0.8 + (10)^2(0.008) = \boxed{1.6\,\Omega}$

$X_{ep} = X_p + a^2 X_s = 3 + (10)^2(0.03) = \boxed{6\,\Omega}$

2400/240

$aV_s \neq V_p$ V_s

$\frac{E_p}{E_s} = a$, $\frac{V_p}{V_s} \neq a$ not ideal



- $\hat{R}_{ep}\hat{I}_p$ is parallel to $\hat{I}_p$
- $jX_{ep}\hat{I}_p$ is perpendicular to $\hat{I}_p$ (inductance)

b. $\vec{V}_p = (R_{ep} + jX_{ep})\vec{I}_p + a\vec{V}_s$

$\vec{V}_s = 240 \angle 0^\circ \ V$

$a\vec{V}_s = 10\vec{V}_s = 2400 \angle 0^\circ \ V$

$\vec{I}_s = ?$

$|S| = V_s I_s \longrightarrow I_s = \frac{|S|}{V_s} = \frac{20\,000}{240} = 83.3 \ A$

$\phi = \cos^{-1} 0.8 = \angle -36.87^\circ \ A$ (negative because lagging)

$\therefore \vec{I}_s = 83.3 \ A \angle -36.87^\circ A$

$\vec{I}_p = \frac{I_s}{a} = 8.33 \angle -36.87^\circ \ A$

$\vec{V}_p = (1.6 + j6)(8.33 \angle -36.87^\circ) + 2400 \angle 0^\circ$

$= \boxed{2440.86 \angle 0.75^\circ V}$