ECE 320

1. Problem 2.2 A single phase power system is shown in Figure P2-1. The power source feeds a 100 kVA, 14kV / 2.4 kV transformer through a feeder impedance of 38.2+j140 ohm. The transformer's equivalent series impedance refered to its low voltage side is 0.10 + j 0.4 ohm. the load on the transformer is 90kW at 0.80 pf lagging and 2300 V.
a. What is the voltage at the power source of the system?
b. What is the voltage regulation of the transformer?
c. How efficient is the overall power system?

$j := \sqrt{-1}$

a. What is the voltage at the power source of the system?

Rewrite the given.

$S_T := 100 \cdot kV \cdot A$ $\quad Z_F := (38.2 + j \cdot 140) \cdot ohm$ $\quad Z_T := (0.10 + j \cdot 0.40) \cdot ohm$

$P_{Load} := 90 \cdot kW$ $\quad pf_{Load} := 0.80$ lagging $\quad V_{Load} := 2300 \cdot V$ $\quad N_T := \frac{14.4 \cdot kV}{2400 \cdot V}$ $\quad N_T = 6$

$pf_{Load} := 0.85$

Calculate the load current from the given data.

$I_{Load} := \frac{P_{Load}}{V_{Load} \cdot pf_{Load}}$ $\quad I_{Load} = 46.036\,A$ $\quad \theta_{Load} := acos(pf_{Load})$ $\quad \theta_{Load} = 31.788 \cdot deg$

$I_{Load} := I_{Load} \cdot e^{-j \cdot \theta_{Load}}$ $\quad I_{Load} = (39.13 - 24.251i)\,A$

$Z_T = (0.1 + 0.4i)\,\Omega$

Calculate the currents and voltages in the system in sequence through the load.

$V_2 := V_{Load} + I_{Load} \cdot Z_T$ $\quad V_2 = (2.314 + 0.013i) \cdot kV$ $\quad |V_2| = 2.314 \times 10^3\,V$ $\quad arg(V_2) = 0.328\,deg$

$V_1 := N_T \cdot V_2$ $\quad V_1 = (13.882 + 0.079i) \cdot kV$

$I_1 := \frac{I_{Load}}{N_T}$ $\quad I_1 = (6.522 - 4.042i)\,A$

$V_{source} := V_1 + I_1 \cdot Z_F$ $\quad V_{source} = (14.697 + 0.838i) \cdot kV$ $\quad |V_{source}| = 14.721 \cdot kV$

$arg(V_{source}) = 3.263 \cdot deg$

b. What is the voltage regulation of the transformer?

Voltage regulation is found by comparing the no load output voltage to the loaded output voltage. Find the no load output voltage first. At no load, there is no current in the model given. Therefore, the no load voltage is the reflected primary voltage.

$$V_{NL} := \frac{V_1}{N_T} \qquad V_{NL} = (2.314 + 0.013i)\cdot kV \qquad \left|V_{NL}\right| = 2.314\cdot kV$$

$$\arg\left(V_{NL}\right) = 0.328\cdot deg$$

We already have the loaded output voltage. Calculate the voltage regulation.

$$V_{regulation} := \frac{\left|V_{NL}\right| - \left|V_{Load}\right|}{\left|V_{Load}\right|} \qquad V_{regulation} = 0.594\cdot\%$$

$$V_{Load} = 2.3\cdot kV$$

c. How efficient is the overall power system?

Operating data is given different than rated data. Efficiency is power out divided by power in.

$$P_{out} := \mathrm{Re}\left(V_{Load}\cdot\overline{I_{Load}}\right) \qquad P_{out} = 90\cdot kW$$

$$P_{in} := \mathrm{Re}\left(V_{source}\cdot\overline{I_1}\right) \qquad P_{in} = 92.461\cdot kW$$

$$\eta := \frac{P_{out}}{P_{in}} \qquad \eta = 97.339\cdot\%$$

2. Problem 2.3 The secondary winding of a transformer has a terminal voltage of $v_s(t)$=282.8 sin 377t V. The turns ratio of the transformer is 100:200 (a=0.50)

If the secondary current of the transformer is $i_s(t)$=7.07 sin(377t-36.87 degrees)A, what is the primary current of this transformer?

$$j := \sqrt{-1}$$

What are its voltage regulation and efficiency?

Restate the given information:

$$\omega_s := 377\cdot\frac{rad}{sec} \qquad V_{spk} := 282.8\cdot V \qquad I_{spk} := 7.07\cdot A \qquad \theta_s := -36.87\cdot deg \qquad N_t := \frac{100}{200} = 0.5$$

Convert the peak values to rms. Set the phase angle on the secondary voltage to zero and apply the phase angle on the current.

$$V_s := \frac{V_{spk}}{\sqrt{2}} = 199.97\,V \qquad I_s := \frac{I_{spk}}{\sqrt{2}}\cdot e^{j\cdot\theta_s} = (3.999 - 3i)\,A \qquad \left|I_s\right| = 4.999\,A \qquad \arg\left(I_s\right) = -36.87\cdot deg$$

Using the turns ratio, calculate the voltage and current on the primary side of the internal "ideal" transformer. The phase angles are zero and θs, respectively.

$$V_P := V_s \cdot N_t = 99.985\,V \qquad I_P := \frac{I_s}{N_t} = (7.999 - 5.999i)\,A \qquad \left|I_P\right| = 9.998\,A \qquad \arg\left(I_P\right) = -36.87 \cdot deg$$

To put the answer in the same form as the question,

$$i_p(t) = 10 \cdot \sqrt{2} \cdot \sin(377 \cdot t - 36.87 \cdot deg) \cdot A$$

It is an ideal transformer. Its voltage regulation is ZERO and its efficiency is 1.00.

3. Problem 2.6 A 1000 VA 230 V / 115 V transformer has been tested to determine its equivalent circuit. The results of the tests are shown below.
a. Find the equivalent circuit for this transformer refered to the low voltage side of the transformer.
b. Find the transformer's voltage regulation at rated conditions and at (1) 0.8 pf lag, (2) 1.0 pf, and (3) 0.8 pf lead.

Open circuit test secondary LV side	**Short circuit test primary HV side**
$V_{OC} := 115 \cdot V$	$V_{SC} := 17.1 \cdot V$
$I_{OC} := 0.11 \cdot A$	$I_{SC} := 8.7 \cdot A$
$P_{OC} := 3.9 \cdot W$	$P_{SC} := 38.1 \cdot W$

$$j := \sqrt{-1}$$

a. Find the equivalent circuit for this transformer refered to the low voltage side of the transformer.

For the open circuit data,

$$Y_E := \frac{I_{OC}}{V_{OC}} = 9.565 \times 10^{-4} \frac{1}{\Omega} \qquad G_C := \frac{P_{OC}}{V_{OC}^2} = 2.949 \times 10^{-4} \frac{1}{\Omega}$$

$$B_M := \sqrt{Y_E \cdot Y_E - G_C \cdot G_C} = 9.099 \times 10^{-4} \frac{1}{\Omega} \qquad R_C := \frac{1}{G_C} = 3.391\,k\Omega \qquad X_M := \frac{1}{B_M} = 1.099\,k\Omega$$

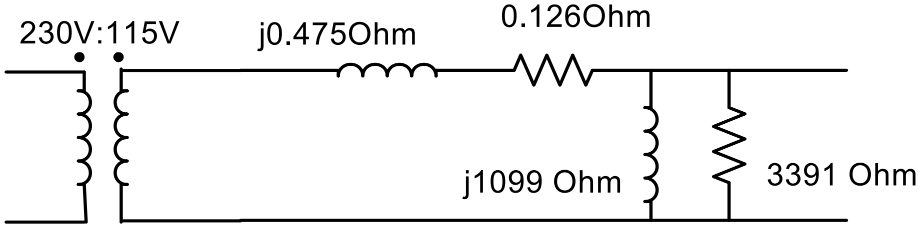
For the short circuit data,

$$Z_{SE} := \frac{V_{SC}}{I_{SC}} = 1.966\,\Omega \qquad R_{eq} := \frac{P_{SC}}{I_{SC}^2} = 0.503\,\Omega \qquad X_{eq} := \sqrt{Z_{SE} \cdot Z_{SE} - R_{eq} \cdot R_{eq}} = 1.9\,\Omega$$

Short circuit data is on the HV side. To convert to the LV side,

$$N_T := \frac{230 \cdot V}{115 \cdot V} = 2$$

$$R'_{eq} := \frac{R_{eq}}{N_T^{\,2}} = 0.126\,\Omega \qquad X'_{eq} := \frac{X_{eq}}{N_T^{\,2}} = 0.475\,\Omega$$



b. Find the transformer's voltage regulation at rated conditions and at (1) 0.8 pf lag, (2) 1.0 pf, and (3) 0.8 pf lead.

Voltage regulation related no load output voltage to loaded output voltage. Rewriting the given,

$$V_P := 230\cdot V \quad V_S := 115\cdot V \qquad S_T := 1000\cdot V\cdot A \qquad N_T := \frac{V_P}{V_S} \qquad N_T = 2$$

At pf=0.80 lagging $\qquad pf_{Load} := 0.8$ $\qquad$ lagging

Find the load current, referred to the low voltage (load) side.

$$V_S = 115\,V \qquad I_{Load} := \frac{S_T}{V_S} \quad I_{Load} = 8.696\,A \quad \theta_{Load} := \operatorname{acos}(pf_{Load}) \qquad \theta_{Load} = 36.87\cdot deg$$

$$I_{Load} := I_{Load}\cdot e^{-j\cdot\theta_{Load}} \qquad I_{Load} = (6.957 - 5.217i)\,A$$

Find the loaded source voltage, referred to the load side,.

$$I_S := I_{Load} + \frac{V_S}{R_C} + \frac{V_S}{j\cdot X_M} = (6.99 - 5.322i)\,A$$

$$V'_{Source} := V_S + I_S\cdot\left(R'_{eq} + j\cdot X'_{eq}\right) = (118.408 + 2.651i)\,V \qquad \left|V'_{Source}\right| = 118.437\,V$$

$$\arg\left(V'_{Source}\right) = 1.282\cdot deg$$

At no load, output voltage is essentially equal to reflected input voltage. Finding the voltage regulation,

$$V_{NL} := V'_{Source} \qquad V_{NL} = (118.408 + 2.651i)\,V \qquad \left|V_{NL}\right| = 118.437\,V$$

$$V_{Regulation} := \frac{\left|V_{NL}\right| - \left|V_S\right|}{\left|V_S\right|} \qquad V_{Regulation} = 2.989\cdot\%$$

Repeat for 1.0 power factor.

At pf=1.0 $\quad pf_{Load} := 1.0$

Find the load current, referred to the low voltage (load) side.

$V_S = 115\,V \qquad I_{Load} := \dfrac{S_T}{V_S} \quad I_{Load} = 8.696\,A \quad \theta_{Load} := acos(pf_{Load}) \qquad \theta_{Load} = 0\cdot deg$

$I_{Load} := I_{Load}\cdot e^{-j\cdot\theta_{Load}} \qquad I_{Load} = 8.696\,A$

Find the loaded source voltage, referred to the load side,.

$$I_S := I_{Load} + \frac{V_S}{R_C} + \frac{V_S}{j\cdot X_M} = (8.73 - 0.105i)\,A$$

$V'_{Source} := V_S + I_S\cdot\left(R'_{eq} + j\cdot X'_{eq}\right) = (116.148 + 4.133i)\,V \qquad \left|V'_{Source}\right| = 116.222\,V$

$arg\left(V'_{Source}\right) = 2.038\cdot deg$

At no load, output voltage is essentially equal to reflected input voltage. Finding the voltage regulation,

$V_{NL} := V'_{Source} \qquad V_{NL} = (116.148 + 4.133i)\,V \qquad \left|V_{NL}\right| = 116.222\,V$

$V_{Regulation} := \dfrac{\left|V_{NL}\right| - \left|V_S\right|}{\left|V_S\right|} \qquad V_{Regulation} = 1.062\cdot\%$

Repeat for 0.8 power factor leading.

At pf=0.80 lagging $\quad pf_{Load} := 0.8 \quad$ leading

Find the load current, referred to the low voltage (load) side.

$V_S = 115\,V \qquad I_{Load} := \dfrac{S_T}{V_S} \quad I_{Load} = 8.696\,A \quad \theta_{Load} := -acos(pf_{Load}) \qquad \theta_{Load} = -36.87\cdot deg$

$I_{Load} := I_{Load}\cdot e^{-j\cdot\theta_{Load}} \qquad I_{Load} = (6.957 + 5.217i)\,A$

Find the loaded source voltage, referred to the load side,.

$$I_S := I_{Load} + \frac{V_S}{R_C} + \frac{V_S}{j\cdot X_M} = (6.99 + 5.113i)\,A$$

$V'_{Source} := V_S + I_S\cdot\left(R'_{eq} + j\cdot X'_{eq}\right) = (113.451 + 3.964i)\,V \qquad \left|V'_{Source}\right| = 113.52\,V$

$$\arg(V'_{Source}) = 2.001 \cdot deg$$

At no load, output voltage is essentially equal to reflected input voltage. Finding the voltage regulation,

$$V_{NL} := V'_{Source} \qquad V_{NL} = (113.451 + 3.964i)\ V \qquad |V_{NL}| = 113.52\ V$$

$$V_{Regulation} := \frac{|V_{NL}| - |V_S|}{|V_S|} \qquad V_{Regulation} = -1.287 \cdot \%$$

This is quite common. Capacitive loads often cause a voltage rise across the lines of an AC system.

c. Determine the efficiency at rated conditions and 0.80 power factor lagging.

$S_T = 1 \cdot kV \cdot A \qquad V_P = 230\ V \qquad V_S = 115\ V \qquad pf_{Load} := 0.80$ lagging

$R'_{eq} = 0.126\ \Omega \qquad R_C = 3.391 \cdot K\Omega$

Recall resistances and current, refer to the high voltage (input) side.

$$I_{Load} := \frac{S_T}{V_S} \cdot e^{-j \cdot acos(pf_{Load})} \qquad I_{Load} = (6.957 - 5.217i)\ A \qquad |I_{Load}| = 8.696\ A \qquad \arg(I_{Load}) = -36.87\ deg$$

$$I_S := I_{Load} + \frac{V_S}{R_C} + \frac{V_S}{j \cdot X_M} = (6.99 - 5.322i)\ A$$

$$V'_{Source} := V_S + I_S \cdot (R'_{eq} + j \cdot X'_{eq}) = (118.408 + 2.651i)\ V \qquad |V'_{Source}| = 118.437\ V$$

$$\arg(V'_{Source}) = 1.282 \cdot deg$$

Find the losses; then calculate efficiency.

$$P_{LossS} := (|I_S|)^2 \cdot R'_{eq} \qquad P_{LossS} = 9.714\ W$$

$$P_{LossC} := \frac{(|V_S|)^2}{R_C} \qquad P_{LossC} = 3.9\ W \qquad |V_S| = 115\ V$$

$$P_{out} := Re\left(V_S \cdot \overline{I_{Load}}\right) \qquad P_{out} = 800\ W$$

$$\eta := \frac{P_{out}}{P_{out} + P_{LossS} + P_{LossC}} \qquad \eta = 98.3 \cdot \%$$

Check

$$P_{in} := \mathrm{Re}\left(V'_{Source}\cdot\overline{I_S}\right) = 813.614\,W \qquad \frac{P_{out}}{P_{in}} = 0.983$$

Problem 2.6 A 30 kVA, 8000/230V distribution transformer has an impedance referred to the primary of 20+j100 Ohms. The components of the excitation branch referred to the primary side are R_C=100kΩ and X_M=20kΩ.
a. If the primary voltage is 7967V and the load impedance is Z_L=2.0+j0.7Ω, what is the secondary voltage of the transformer? What is the voltage regulation of the transformer?
b. If the load is disconnected and a capacitor of -j3Ω is connected in its place, what is the secondary voltage of the transformer? What is its voltage regulation under these conditions?

Restate the given. $j := \sqrt{-1}$

$$S_T := 30\cdot kV\cdot A \quad V_P := 8\cdot kV \quad V_S := 230\cdot V \quad R_{eq} := 20\cdot\Omega \quad X_{eq} := 100\cdot\Omega \quad R_C := 100\cdot k\Omega \quad X_M := 20\cdot k\Omega$$

Calculate the turns ratio from the given voltage ratio.

$$N_T := \frac{V_P}{V_S} \qquad N_T = 34.783$$

Initial conditions on the terminal voltage input and the load impedance.

$$V_P := 7967\cdot V \quad Z_L := (2.0 + j\cdot 0.7)\cdot\Omega$$

Convert all impedances to the primary side. All but the load are already there.

$$Z_{LP} := N_T^{\,2}\cdot Z_L \quad Z_{LP} = (2.42 + 0.847i)\cdot k\Omega$$

Write a node equation on the primary side, including the reflected load, and solve for the node voltage.

$$\frac{V_M - V_P}{R_{eq} + j\cdot X_{eq}} + \frac{V_M}{R_C} + \frac{V_M}{j\cdot X_M} + \frac{V_M}{Z_{LP}} = 0$$

$$V_M\cdot\left(\frac{1}{R_{eq} + j\cdot X_{eq}} + \frac{1}{R_C} + \frac{1}{j\cdot X_M} + \frac{1}{Z_{LP}}\right) = \frac{V_P}{R_{eq} + j\cdot X_{eq}}$$

$$V_M := \frac{V_P}{\left(R_{eq} + j\cdot X_{eq}\right)\cdot\left(\frac{1}{R_{eq} + j\cdot X_{eq}} + \frac{1}{R_C} + \frac{1}{j\cdot X_M} + \frac{1}{Z_{LP}}\right)} = \left(7.761\times 10^3 - 259.134i\right)V$$

$$\left|V_M\right| = 7.765\cdot kV$$

Reflect this to the secondary to get the load voltage.

$$\arg(V_M) = -1.912 \cdot deg$$

$$V_L := \frac{V_M}{N_T} \qquad V_L = (223.118 - 7.45i)\,V \qquad |V_L| = 223.242\,V$$

$$\arg(V_L) = -1.912 \cdot deg$$

To get the voltage regulation, first find the open circuit voltage. We do this by voltage division.

$$Z_M := \frac{R_C \cdot j \cdot X_M}{R_C + j \cdot X_M} \qquad Z_M = \left(3.846 \times 10^3 + 1.923i \times 10^4\right)\Omega$$

$$V_{MOC} := \frac{V_P \cdot Z_M}{Z_M + R_{eq} + j \cdot X_{eq}} \qquad V_{MOC} = 7.926 \times 10^3\,V \qquad |V_{MOC}| = 7.926 \cdot kV$$

Calculate voltage regulation.

$$V_{reg} := \frac{|V_{MOC}| - |V_M|}{|V_M|} \cdot 100 \cdot \% \qquad V_{reg} = 2.071 \cdot \%$$

Part b.

Initial conditions on the terminal voltage input and the load impedance.

$$V_P := 7967 \cdot V \qquad Z_L := (-j \cdot 3) \cdot \Omega$$

Convert all impedances to the primary side. All but the load are already there.

$$Z_{LP} := N_T^{\,2} \cdot Z_L \qquad Z_{LP} = -3.629i \cdot k\Omega$$

Write a node equation on the primary side, including the reflected load, and solve for the node voltage.

$$\frac{V_M - V_P}{R_{eq} + j \cdot X_{eq}} + \frac{V_M}{R_C} + \frac{V_M}{j \cdot X_M} + \frac{V_M}{Z_{LP}} = 0$$

$$V_M \cdot \left(\frac{1}{R_{eq} + j \cdot X_{eq}} + \frac{1}{R_C} + \frac{1}{j \cdot X_M} + \frac{1}{Z_{LP}}\right) = \frac{V_P}{R_{eq} + j \cdot X_{eq}}$$

$$V_M := \frac{V_P}{\left(R_{eq} + j \cdot X_{eq}\right) \cdot \left(\frac{1}{R_{eq} + j \cdot X_{eq}} + \frac{1}{R_C} + \frac{1}{j \cdot X_M} + \frac{1}{Z_{LP}}\right)} = \left(8.149 \times 10^3 - 45.93i\right)V$$

$$|V_M| = 8.149 \cdot kV$$

Reflect this to the secondary to get the load voltage.

$$\arg(V_M) = -0.323 \cdot deg$$

$$V_L := \frac{V_M}{N_T} \qquad V_L = (234.281 - 1.32i)\,V \qquad |V_L| = 234.284\,V$$

$$\arg(V_L) = -0.323 \cdot deg$$

To get the voltage regulation, first find the open circuit voltage. We do this by voltage division.

$$Z_M := \frac{R_C \cdot j \cdot X_M}{R_C + j \cdot X_M} \qquad Z_M = (3.846 + 19.231i) \cdot k\Omega$$

$$V_{MOC} := \frac{V_P \cdot Z_M}{Z_M + R_{eq} + j \cdot X_{eq}} \qquad V_{MOC} = 7.926 \times 10^3\,V \qquad |V_{MOC}| = 7.926 \cdot kV$$

Calculate voltage regulation.

$$V_{reg} := \frac{|V_{MOC}| - |V_M|}{|V_M|} \cdot 100 \cdot \% \qquad V_{reg} = -2.739 \cdot \%$$

The capacitor gives us a voltage rise across the transformer.

Pr**oblem 2.14 A 13.8 kV single phase generator supplies power to a load through a transmission line. The load's impedance is 500 ohms at an inductive angle of 36.87 degrees. The transmission line's impedance is 60 ohms at an inductive angle of 60 degrees.**
a. If the generator is directly connected to the load as shown in Figure 2.3a, what is the ratio of the load voltage to the generated voltage? What are the transmission losses of the system?
b. If a 1:10 step up transformer is placed at the output of the generator and a 10:1 transformer is placed at the load end of the transmission line, what is the new ratio of load voltage to generated voltage? What are transmission losses of the system now? Assume transformers to be ideal.

$$V_G := 13.8 \cdot kV \qquad Z_{Load} := 500 \cdot e^{j \cdot 36.87 \cdot deg} \cdot ohm \qquad Z_{line} := 60 \cdot e^{j \cdot 60 \cdot deg} \cdot ohm \qquad N_T := 10$$

$$Z_{Load} = (399.999 + 300.001i)\,\Omega \qquad Z_{line} = (30 + 51.962i)\,\Omega$$

a. If the generator is directly connected to the load as shown in Figure 2.3a, what is the ratio of the load voltage to the generated voltage? What are the transmission losses of the system?

A voltage division finds the load voltage.

$$V_{Load} := V_G \cdot \frac{Z_{Load}}{Z_{Load} + Z_{line}} \qquad V_{Load} = (12.406 - 0.527i) \cdot kV \qquad \frac{|V_{Load}|}{|V_G|} = 0.9$$

For line losses, find the current first and then calculate losses.

$$I_{line} := \frac{V_G - V_{Load}}{Z_{line}} \qquad I_{line} = (19.218 - 15.73i)\,A \qquad |I_{line}| = 24.835\,A$$

$$P_{loss} := \left(|I_{line}|\right)^2 \cdot Re(Z_{line}) \qquad P_{loss} = 18.503 \cdot kW$$

b. What percentage of the power supplied by the source reaches the load?

$$P_{Load} := Re\left(V_{Load} \cdot \overline{I_{line}}\right) = 246.702\,kW$$

$$\eta_b := \frac{P_{Load}}{P_{Load} + P_{loss}} = 0.93$$

c. If a 1:10 step up transformer is placed at the output of the generator and a 10:1 transformer is placed at the load end of the transmission line, what is the new ratio of load voltage to generated voltage? What are transmission losses of the system now? Assume transformers to be ideal.

Reflect everything to the generator side for reference.

$$V_G = 13.8 \cdot kV \qquad Z_{Load} := Z_{Load} \cdot N_T^{\,2} \cdot \frac{1}{N_T^{\,2}} \qquad Z_{Load} = (399.999 + 300.001i)\,\Omega$$

$$Z_{line} := Z_{line} \cdot \frac{1}{N_T^{\,2}} \qquad Z_{line} = (0.3 + 0.52i)\,\Omega$$

Do a voltage division to find load voltage.

$$V_{Load} := V_G \cdot \frac{Z_{Load}}{Z_{Load} + Z_{line}} \quad V_{Load} = \left(13.785 - 6.491i \times 10^{-3}\right) \cdot kV \quad |V_{Load}| = 13.785 \cdot kV \quad \frac{|V_{Load}|}{|V_G|} = 0.999$$

Because the two transformers have the same turns ratio, this value is equal to the load voltage.
Now find the losses.

$$I_{line} := \frac{V_G - V_{Load}}{Z_{line}} \qquad I_{line} = (22.048 - 16.552i)\,A$$

$$P_{loss} := \left(|I_{line}|\right)^2 \cdot Re(Z_{line}) \qquad P_{loss} = 228.024 \cdot W$$

d. What percentage of the power supplied by the source reaches the load?

$$P_{Load} := Re\left(V_{Load} \cdot \overline{I_{line}}\right) = 304.032\,kW$$

$\eta_b := \frac{P_{Load}}{P_{Load} + P_{loss}} = 0.999$

e. Compare the efficiencies of the transmission system with and without transformers.

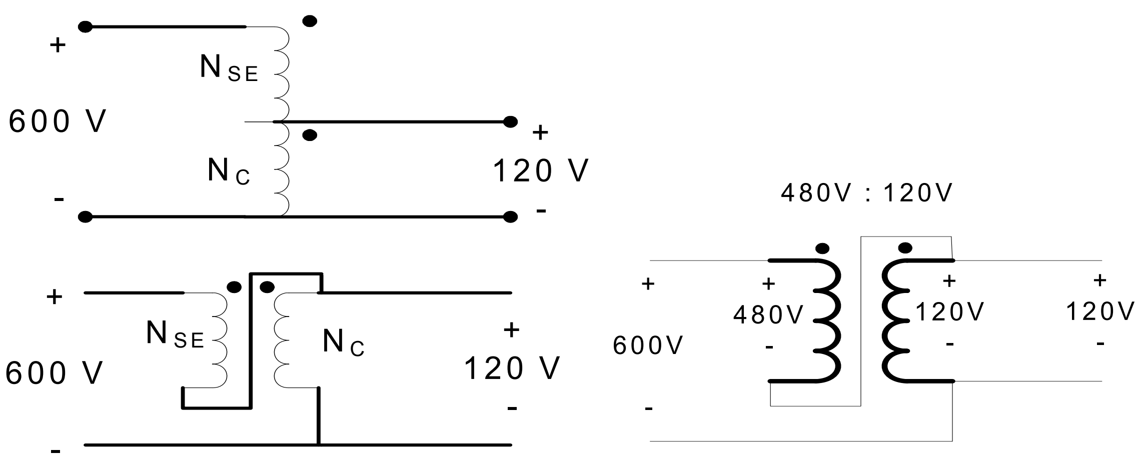
Dramatically improved by the use of transformers.

Problem 2.15 A 10,000 VA, 480V / 120V conventional transfomer is to be used to supply power froma 600V source to 120V load. Consider the transformer to be ideal and assume that all insulation can handle 600V.
a. Sketch the transformer connection that will do the required job.
b. Find the kVA rating of the transformer in the configuration.
c. Find the maximum primary and secondary currents under these conditions.

$S_T := 10000 \cdot V \cdot A \qquad V_P := 480 \cdot V \qquad V_S := 120 \cdot V$

a. Sketch the transformer connection that will do the required job.

Here are three ways to connect the transformer. They are actually the same, but the diagram for the transformer itself is different in each case.



b. Find the kVA rating of the transformer in the configuration.

$V_{in} := 600 \cdot V \qquad V_{out} := 120 \cdot V$

$I_P := \frac{S_T}{V_P} \qquad I_P = 20.833\,A \qquad I_S := \frac{S_T}{V_S} \qquad I_S = 83.333\,A$

The input has the same current as the original transformer's primary

$I_{in} := I_P$ $\qquad$ $I_{in} = 20.833\,A$

the output current is the sum of the two winding currents of the original transformer.

$I_{out} := I_P + I_S$ $\qquad$ $I_{out} = 104.167\,A$

The kVA rating can be found from either side, if the transformer is considered to be ideal.

$KVA_{in} := V_{in} \cdot I_{in}$ $\qquad$ $KVA_{in} = 12.5 \cdot kV \cdot A$

$KVA_{out} := V_{out} \cdot I_{out}$ $\qquad$ $KVA_{out} = 12.5 \cdot kV \cdot A$

c. Find the maximum primary and secondary currents under these conditions.

$I_P := \dfrac{S_T}{V_P}$ $\qquad$ $I_P = 20.833\,A$ $\qquad$ $I_S := \dfrac{S_T}{V_S}$ $\qquad$ $I_S = 83.333\,A$

The input current is the same as the primary current; the output current is, as found above, larger than the secondary current.

$I_{out} = 104.167\,A$