ECE 320 / ECE 329

1. (5 points) A small power system is configured as shown in Figure 1. The line reactance is j0.35 Ohms. Both ideal transformers have a 5:1 turns ratio. For an output of 1.0MVA, 480V AC rms, 0.94 power factor at full load, find the voltage regulation.

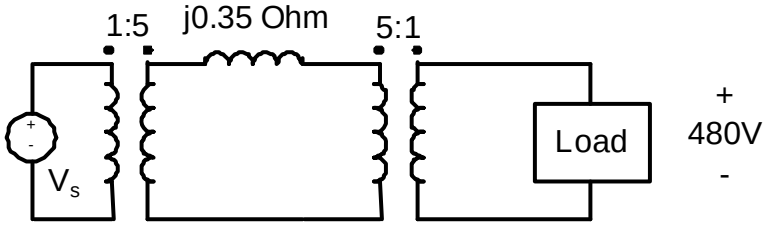


Figure 1. Small Electric Power System.

$$MVA := 10^6 \cdot V \cdot A \qquad j := \sqrt{-1}$$

$$V_L := 480 \cdot V \qquad pf_L := 0.94 \qquad S_L := 1.0 \cdot MVA \qquad N_t := 5 \qquad Z_{line} := 1.4 \cdot \Omega$$

Find the current.

$$\theta_L := \operatorname{acos}(pf_L) = 19.948 \cdot deg \qquad I_L := \overline{\left(\frac{S_L \cdot e^{j \cdot \theta_L}}{V_L} \right)} = \left(1.958 \times 10^3 - 710.78i\right) A$$

Reflect the line impedance and the source impedance to the load side. This divides the line impedance by the square of the turns ratio, but the offsetting transformers have no net effect on the reflected source voltage.

$$Z'_{line} := \frac{Z_{line}}{N_t^2} = 0.056\,\Omega$$

Calculate the source voltage.

$$V_s := V_L + I_L \cdot j \cdot Z'_{line} = (519.804 + 109.667i)\,V \qquad |V_s| = 531.246\,V$$

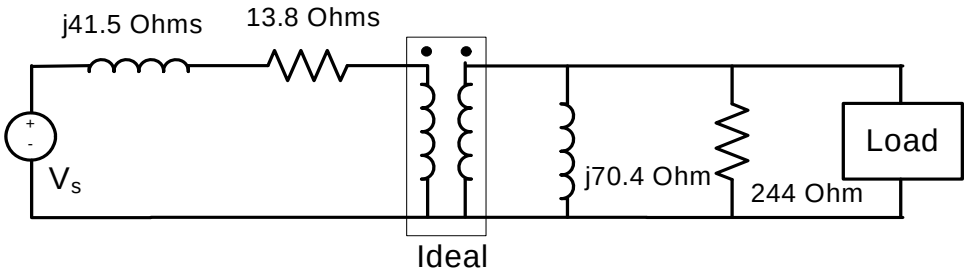
Find the voltage regulation. The no load voltage is equal to the source voltage.

$$V_{reg} := \frac{|V_s| - |V_L|}{|V_L|} = 10.676 \cdot \%$$

2. (5 points) A 50kVA, 4160V:480V transformer has the following parameters for its Steinmetz equivalent circuit:

R_{eq} = 13.8 Ohms	Series winding resistance referred to the high voltage side
X_{eq} = 41.5 Ohms	Series leakage reactance referred to the high voltage side
X_M = 92 Ohms	Magnetizing reactance referred to the low voltage side
R_C = 460 Ohms	Core loss resistance referred to the low voltage side

a. (1 point) Draw an appropriate equivalent circuit for this transformer. Label each circuit element.



Showing the source and load are optional in answering this problem.

b. (4 points) When a short circuit test is conducted according to the method prescribed in the textbook, what would you expect the voltage measurement to be?

$R_{eq} := 13.8 \cdot \Omega$ $X_{eq} := 41.5 \cdot \Omega$ $X_M := 92 \cdot \Omega$ $R_C := 460 \cdot \Omega$

The short circuit input current should be the rated current, found by dividing the apparent power by the terminal voltage on the High Voltage side.

$$I_{SC} := \frac{50 \cdot kV \cdot A}{4160 \cdot V} = 12.019\ A$$

The voltage is found from a loop equation. The transformer is short circuited. The measurement will be the magnitude of this voltage.

$$V_{SC} := I_{SC} \cdot \left(R_{eq} + j \cdot X_{eq}\right) = (165.865 + 498.798i)\ V$$

$$\left|V_{SC}\right| = 525.653\ V$$