Last Name: LITION

First Name: SOL

ENEL 487 Midterm Examination

March 11, 2019

10:00 - 10:50 am

Instructor: Pouyan (Yani) Jazayeri

- Exam consists of 3 problems.
- Write answers in the space provided below each question.
- Show your work neatly in the work area. Otherwise, marks for partially correct answers cannot be given.
- Total marks for the exam is 23.
- Closed book exam. You may not refer to books or notes during the test.
- No wireless devices or earphones allowed during exam.
- Only scientific calculators without formulae storage and text display are allowed.

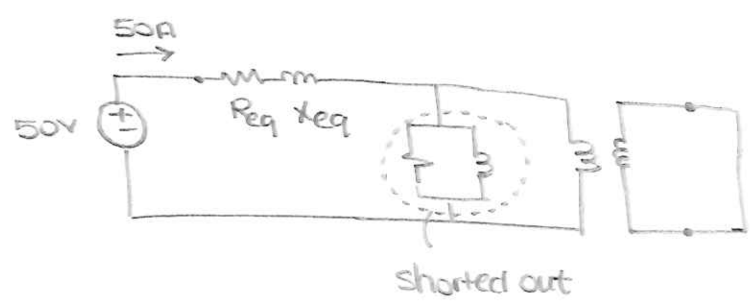
Problem 1:

Your colleague has purchased a single phase, 48kVA, 480/120 V distribution transformer from a country with lax attitudes towards honesty and standards! Going through the transformer test report, you have found the following data for the short circuit test:
Applied voltage to the HV winding = 50V, measured current = 50A, real power measured = 1500 W

a) Which transformer model parameters are calculated in this test? Calculate their values. [3 marks]

- R_{eq} & X_{eq}
- $R_{eq} = \frac{P_{SC}}{I_{HV}^2} = \frac{1500\ W}{(50A)^2} = 0.6\ \Omega$
- $|Z_{eq}| = \frac{V_{HV}}{I_{HV}} = \frac{50V}{50\ A} = 1\Omega$
- $X_{eq} = \sqrt{|Z_{eq}|^2 - R_{eq}^2} = 0.8\ \Omega$

not needed for the solution:



b) The salesperson representing the manufacturer claims that the transformer windings are made of ideal, lossless conductors. Can you verify or dispute this claim based on the available information. Justify your answer [1 mark]

R_{eq} is used in the non-ideal txfr model to capture copper losses in the winding. $R_{eq} \neq 0$ $\therefore$ winding conductors are not ideal.

c) The rated values for a Δ-Y transformer are 96kVA, 2400/240 V. The HV side is Δ-connected and the LV side is Y-connected.
The rated current for the HV side is 23.09 A [1 mark] $I_{rated_{HV}} = \frac{S_{rated}}{\sqrt{3}\, V_{rated_{HV}}}$

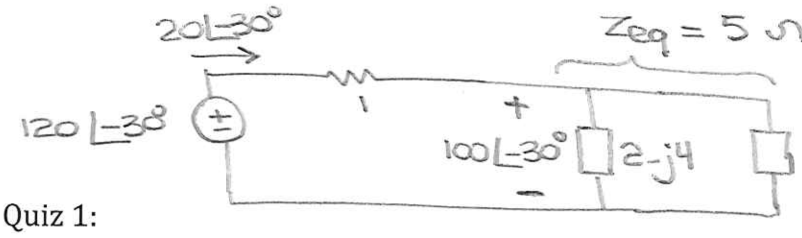
The maximum current in each winding on the HV side is $13.\overline{3}$ A [1 mark]

I_{rated} is the rated line current.

in the Δ connection, $I_\phi = \frac{I_\ell}{\sqrt{3}}$

if the max line current is 23.09 A, max current in each phase (winding) is $\frac{23.09}{\sqrt{3}}$ A

Problem 2:



This is the same system as Problem 2 on Quiz 1:

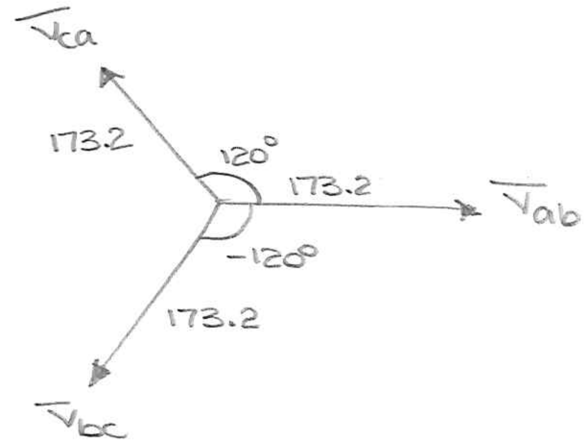
A balanced Δ-connected load (Load 1) with impedance of 6+j12 Ω per phase is connected in parallel with a balanced Y-connected load (Load 2) with impedance of 2-j4 Ω per phase. A line with impedance of 1 Ω per phase connects these loads to a 208V source.

In the per-phase circuit, load voltage was calculated to be 100∠-30° and the current in the line was calculated to be 20∠-30°

a) Draw a phasor diagram showing all 3 phase voltages for Load 1. Provide the name, magnitude, and phase angle for each phasor in your diagram [3 marks]

$\bar{V}_{load}$ in the per phase circuit is the line-to-neutral voltage at the load, say $\bar{V}_{an}$.

$$\bar{V}_{ab} = \bar{V}_{an}\,(\sqrt{3}\angle 30^\circ) = 100\sqrt{3}\angle{-30+30^\circ}$$
$$= 173.2\angle 0^\circ$$



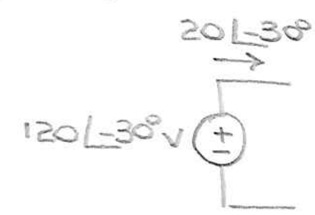
b) Calculate the total power losses in the line. Include the units in your answer [1 mark]

$$P_{3\phi} = 3 \times I^2 \cdot R = 3 \times (20A)^2 \times 1 = 1200 \text{ W}$$

$$Q_{3\phi} = 0$$

c) Calculate the power factor for the source in the per-phase circuit. [2 marks]

$$PF = \cos(\theta_{V\,source} - \theta_{I\,source}) = \cos(-30-(-30)) = 1$$

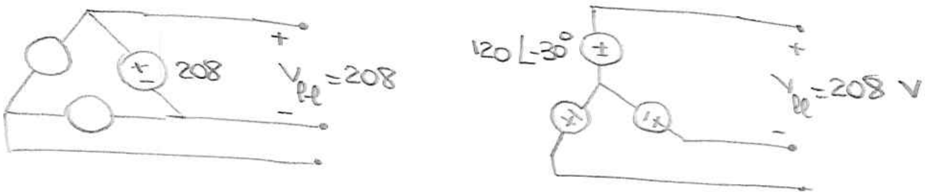


alternatively, line & Z_{eq} of the load are both purely resistive

∴ Source only provides real power ∴ PF = 1

d) Is the source Y-connected or Δ-connected? Explain. [1 mark]

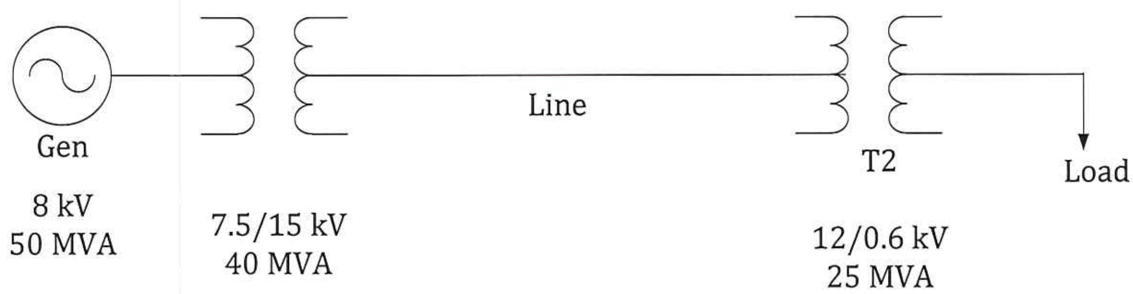
Don't know! All we know about the source is that it provides a l-l voltage of 208 V. A Y- or Δ- connected source can provide this



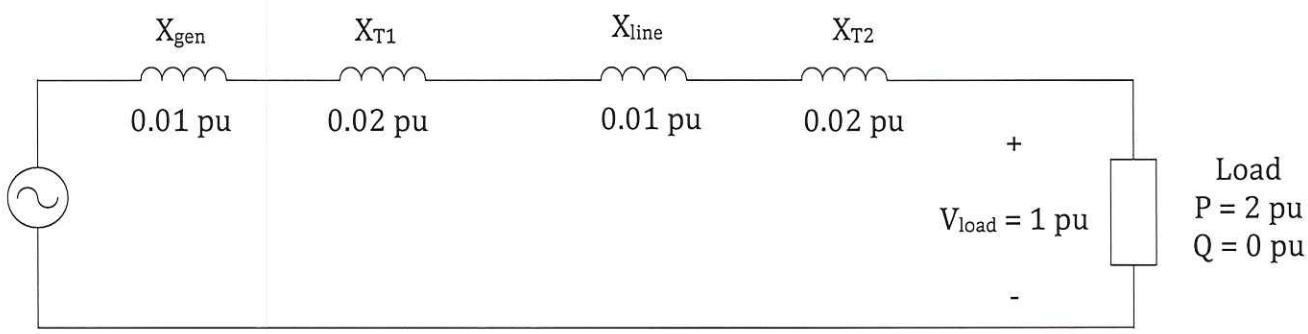
Zone 1 | Zone 2 | Zone 3

Problem 3:

Following is a single line diagram of a three phase system:



The corresponding per unit circuit (impedance diagram) is shown below:



The following base values were used: S_{base} = 100 MVA, V_{base}= 7.5kV in Gen zone

a) Calculate the total three phase power of the load. Include the units in your answer. [1 mark]

$$P_{3\phi} = P_{pu} \times S_{base} = 2 \times 100 = 200 \text{ mW}$$

$$Q_{3\phi} = 0 \text{ mVAr}$$

b) Calculate the magnitude of the line-to-line voltage at the load. [2 marks]

Need V_{base} for load zone.

$$V_{base_2} = V_{base_1} \times \frac{15}{7.5} = 15 \text{ kV}$$

$$V_{base_3} = V_{base_2} \times \frac{0.6}{12} = 0.75 \text{ kV}$$

$$V_{load,ll} = V_{load} \times V_{base_3} = 1 \times 0.75 = 0.75 \text{ kV}$$

c) Calculate the reactance of the line in Ohms. [2 marks]

$$X_{line,\Omega} = X_{line,pu} \times Z_{base_2} = 0.01 \times \frac{(V_{base_2})^2}{S_{base}}$$

$$= 0.01 \times \frac{(15 \text{ kV})^2}{100 \text{ mVA}}$$

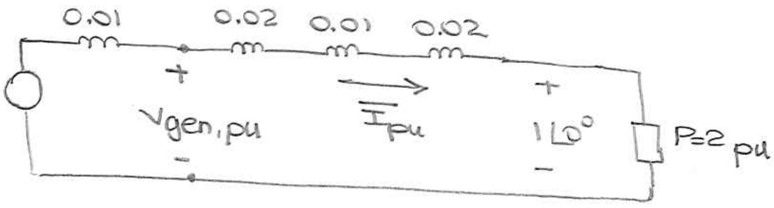
$$= 0.0225 \ \Omega$$

d) Calculate the reactance of T1 in Ohms referred to the HV side [2 marks]

$$X_{T1,\Omega} = X_{T1,pu} \times Z_{base_2} = 0.02 \times 2.25 = 0.045\ \Omega$$

e) Calculate the magnitude of the line-to-line voltage at the generator terminals. [3 marks]

Need $\overline{I}_{pu}$!



$$\overline{I}_{pu} = \frac{\overline{S}^{*}_{load,pu}}{\overline{V}^{*}_{load,pu}} = \frac{2\angle 0°\ pu}{1\angle 0°\ pu} = 2\angle 0°\ pu$$

$$\overline{V}_{gen,pu} = \overline{V}_{load} + \overline{I}_{pu}\left(jX_{T2} + jX_{line} + jX_{T1}\right)$$

$$= 1\angle 0° + 2\angle 0°\,(j\,0.05)$$

$$= 1 + j\,0.1$$

$$= 1.005\angle 5.7°$$

$$V_{gen,l\text{-}l} = 1.005 \times V_{base_1} = 7.54\ V$$

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Question	1	2	3	Total
Mark	/6	/7	/10	/23