LUT University

LUT School of Energy Systems / Electrical Engineering

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CALCULATOR IS ALLOWED
MATERIALS ARE NOT ALLOWED

BL20A0710 Introduction to Electrical Power Systems

Exam 7.5.2026

1. Explain shortly the following terms (max 20 points):
    a. Per-unit value
    b. Surge arrester
    c. Disconnector
    d. Current transformer
    e. Life-time costs

2. Read the following five statements carefully and state whether they are correct or not. Answer 'YES', 'NO' or 'I do not know'. By giving a correct answer, you will get +4 points, and by providing a wrong answer, you will get -4 points. If you do not give any answer, you will get 0 points. The minimum points for the whole task are 0 (your result cannot be below zero). (max 20 points)

    a. The power angle equation determines the power factor of the load flowing in the power line.
    b. During a short circuit, an induction motor temporarily operates as a generator feeding energy into the fault.
    c. In a TN-S system, the neutral conductor is separated from the protective earth conductor.
    d. Each electricity market price area in Nordic countries forms its own frequency area.
    e. No-load losses of the transformer are doubled when the load current doubles.

3. Principles and implementation of frequency control in the Nordic power system. How preparation for disturbances are managed?

4. A three-phase medium-voltage line is 5 km. Resistance is 0.252 Ω/km and reactance is 0.128 Ω/km (inductive). Voltage at the beginning of line is 21.0 kV. At the end of the line load is P = 6 MW with power factor 0.95ind. Draw a 1-phase equivalent diagram and calculate the line voltage and current at the end of the line and the power losses of the line.

5. Rigid network supplies loads through 110/21 kV transformer (Figure 1). Determine 3-phase short circuit current for the point B. Draw 1-phase equivalent diagram. Is the short circuit current higher or lower in point A compared to point B? Voltage is 21 kV before the fault occurs. (max 20 points)

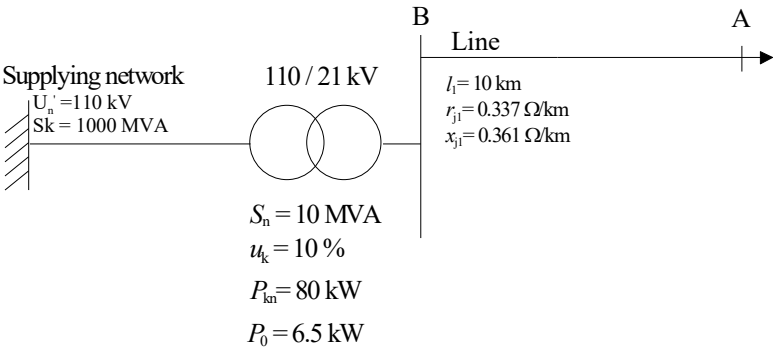

Figure 1.

Some mathematical formulas

Ohm's law $U = Z \cdot I$

Phase Power $S_{1-\text{phase}} = U_{\text{phase}} \cdot I$

Phase voltage $U_{\text{phase}} = \frac{U_{\text{line}}}{\sqrt{3}}$

Power in three-phase system

Apparent power $S = 3 \cdot U_{\text{phase}} \cdot I = \sqrt{3} \cdot U_{\text{line}} \cdot I$

Active power $P = \sqrt{3} \cdot U_{\text{line}} \cdot I \cdot \cos\varphi$

Reactive power $Q = \sqrt{3} \cdot U_{\text{line}} \cdot I \cdot \sin\varphi$

Phasor calculation

$\underline{U}_{phase} = \underline{Z} \cdot \underline{I}$

Phase power $\underline{S}_{1\text{-}phase} = \underline{U}_{\text{phase}} \cdot \underline{I}^*$

Resistance and reactance of transformer $R_{\text{k}} = u_{\text{r}} \frac{U_{\text{N,line}}{}^2}{S_{\text{N}}}$; $X_{\text{k}} = u_{\text{x}} \frac{U_{\text{N,line}}{}^2}{S_{\text{N}}}$

Reactance of generator or motor $X_{\text{d}} = x_{\text{d}} \frac{U_{\text{N,line}}{}^2}{S_{\text{N}}}$

Resistance of transformer

$u_{\text{r}} = \frac{P_{load-loss}}{S_{\text{N}}}$