Tampere University Exam 24.1.2023
EE.EES.420 Electric Power Quality

Pertti Pakonen Programmable calculator allowed 4 questions/ á 6 p

1. What causes fundamental frequency reactive power to occur in distribution networks, what are the consequences of it and how it can be compensated? Give an example of a feasible application for each compensation method.

2. What is flicker and what causes it? Why flicker is harmful and how the intensity of flicker may be evaluated? What characteristics of the source of flicker and the network affect the intensity of flicker? Explain the aspects related to the management of flicker from the viewpoint of a distribution system operator (DSO).

3. a) Why shunt-connected active power filter (APF) is connected close to the load? What are the advantages and disadvantages of a series-connected APF compared to a shunt-connected APF?

   b) What are resonances in electric power networks and how the resonant circuit may be formed? What does resonance frequency mean and why is it relevant? What are the consequences of a resonance and how the risk of a resonance may be mitigated?

4. Consider a three phase short circuit occurring on one feeder of a radially operated 20 kV distribution network supplied by a 110 kV network. The total resistance and reactance of the supplying 110 kV network and the 110 /20 kV main transformer together, transformed to the 20 kV voltage level, are 0.8 ohm and 4 ohm, respectively. The feeder resistance is 0.34 ohm/km and the reactance 0.38 ohm/km. The phase-to-phase voltages in the 20 kV network before the fault are 21 kV.

   a. draw the three phase and single line equivalent circuits of the fault case
   b. explain why and how the voltages in the network change due to the fault
   c. based on calculus, illustrate graphically the dependence of the feeder short circuit current and the substation 20 kV busbar phase-to-phase voltage during the fault on the fault location
   d. explain shortly how the changes in voltage would be different and have to be calculated differently if the fault was a two-phase short circuit