1. Define and explain the following terms:
   a) Reactive power
   b) Total harmonic distortion
   c) Power factor

2. a) Why shunt-connected active power filter (APF) is connected close to the industrial 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? What happens and why when a resonance occurs? What does resonance frequency mean and why is it relevant?

3. In what various ways standards are related to power quality and the management of disturbances in electric power networks. Give examples of how the standards may be applied in practice and what benefits may be achieved by them.

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, transformed to the 20 kV voltage level, are 1 ohm and 5 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 phase 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 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