1) ***Customer voltage level***

   List 5 ways to help keep a customer's voltage within the limits specified by the standards.

2) ***Regulation***

   a) **What part of the electricity business requires regulation and why?**
   b) **What are the main principles of this regulation?** (You can answer this by specific reference to a particular country's regulation model or in general terms)

3) ***Power Quality***

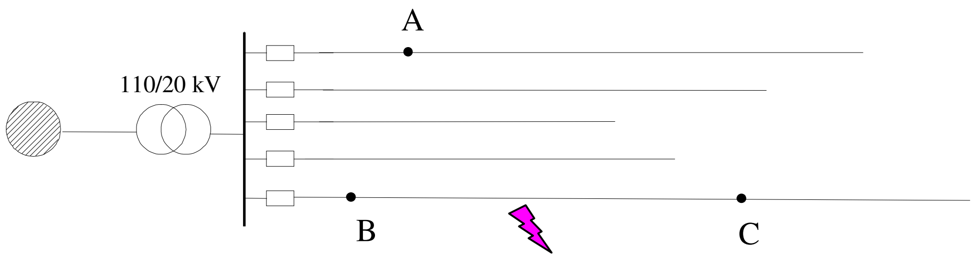

Fig. 1.

I_k= 20 kA (110 kV side)
S_T = 40 MVA, z_k = 10%
$\underline{z}_{feeder}$ = 0.4 + i 0.4 Ω/km
Z_{fault} = 0.0 Ω (5 km from the substation)
A is a point on another feeder fed from the same busbar
B is at a distance of 1 km from the substation on the faulted feeder
C is some point downstream from the fault

Fig. 1 shows a radially operated medium voltage network built with overhead lines and with an autoreclosure sequence in use. A three-phase short circuit with fault impedance $\underline{Z}_{fault}$ = 0.0 Ω occurs at a distance of 5 km from the substation. The fault occurs at time stamp t = 200 ms. The short circuit protection trips the circuit breaker in 200 ms. The dead time of the high-speed autoreclosure is 400 ms. The high-speed autoreclosure is successful and the temporary fault is cleared.

Draw the voltages (as a percentage of their normal value) experienced by customers A, B and C within the time t = 0 – 1000 ms (copy Fig. 2 to your answer sheet). Support your figures with explanations (and calculations) where required. Load currents are not taken into account.

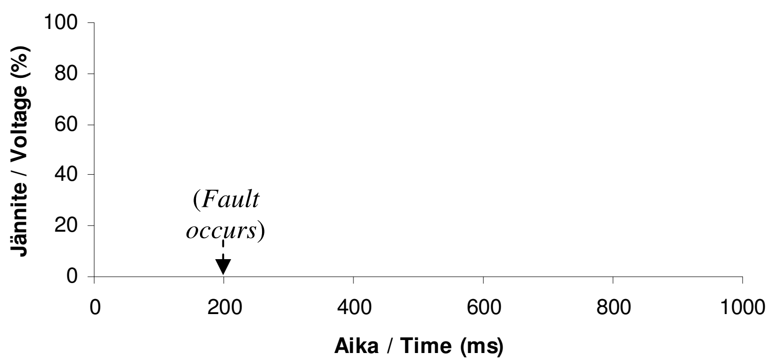

Fig. 2.

The following network (Fig. 3) is to be used for both Questions 4 and 5.

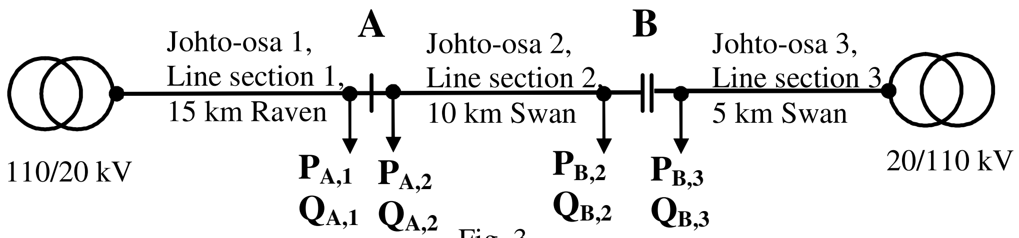

Fig. 3

P_{A1} = 2.0 MW	P_{A2} = 0.5 MW	P_{B2} = 0.5 MW	P_{B3} = 1.0 MW
Q_{A1} = 0.2 MVAr	Q_{A2} = 0.1 MVAr	Q_{B2} = 0.1 MVAr	Q_{B3} = 0.3 MVAr

	Cross-section (mm^2)	**Resistance** (Ω/km)	**Reactance** (Ω/km)	**Max load** current (A)
Raven	54	0.537	0.379	280
Swan	25	1.358	0.416	155

Fault frequency (on all line sections)	0.07 faults/km/year

	Outage costs (€/kW/fault)	**Outage costs** (€/kWh)
All customers	1.0	10

Cost of energy losses based on maximum load flow = 120 €/kW/year

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4) ***Technical constraints***

Check whether the voltage drop and load flow are acceptable for the 20 kV network shown in Fig. 3 for both i) and ii). You do not need to consider the line parameters when calculating the load flows and current**:**

i) **Disconnector A closed and B open (as in the figure)**
ii) **A open and B closed**

5) ***Open point optimisation***

The discount factor (which converts annual costs into lifetime costs), *k*, is 12.5 for loss-related costs and 9.5 for load-related costs (you do not have to calculate these values, we are kindly giving them to you!).

The switch time (to close the open disconnector and open the closed disconnector) is 1 hour and the repair time (which includes the switch time) is 4 hours.

The question is, assuming that all technical constraints are satisfied in Fig. 3, which is the optimum open point (A or B) when considering loss and outage costs?

Why is *k* higher for loss-related costs than load-related costs?